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SCIENTIFIC RESEARCH AND INDUSTRY IN GREAT BRITAIN

THE report from the Department of Scientific and Industrial Research for the year 1948–49 (see p. 971 of this issue) is on the lines of the reports issued annually in the decade or more before the War, and the summary of work which occupies the bulk of the report goes far to meet the criticism of the Select Committee on Estimates three years ago, and more recently of the Committee of Public Accounts, regarding the need for greater detail. This is particularly true with regard to the research associations, and it can fairly be claimed in respect of the present report that sufficiently detailed information is supplied to facilitate independent judgment as to the value to the nation of the work alike of the research associations and the establishments of the Department, and the return obtained from the expenditure of more than three millions from the national exchequer. Moreover, the report of the Advisory Council, with its discussion of broad questions of policy, should inspire every confidence that the expenditure is being directed to the right objectives, and that the Council should be able to count on the full support, not only of the Advisory Council on Scientific Policy, but also of scientific men and industrialists in Britain generally.

In the present report, the Advisory Council is especially concerned with two aspects of general policy. The first is that of the choice of problems; attention was directed to this matter in last year's report. Here the Council's first concern is how best the available resources of the Department can be used for the solution of current national problems. Conferences of the chairmen and directors of the research associations and of the chairmen of the advisory boards held early in the year provide ample evidence of the value of the work which is being done both by the establishments and the research associations within the limits of their present resources, and of the increasing extent to which government departments and industry are turning to them for the solution of technical problems. Nevertheless, it is essential in these critical times that the tasks for which available resources are used should be, not merely useful, but also the most useful that can be undertaken for restoring the prosperity of Great Britain. Further, the Advisory Council insists that it is no less essential to ensure that every practicable step is taken, once a piece of work is finished, to apply the results in practice.

The Advisory Council has here seized the real core of criticism that has been advanced from outside of the work of the boards and of the research associations; and that it has done so should of itself dispose such critics to consider, in the light of the fuller details now disclosed, that the selection of problems is wisely made and in full touch with the particular industries being served. Moreover, so far as certain broad national needs are concerned, it is difficult to conceive of an alternative form of organization to which the choice of problems could more appropriately be entrusted.

For the Department's establishments, the Advisory Council points out, the choice of problems is made primarily on the advice of their respective boards, and the Council is convinced that in general the choice of problems is wisely made. It is difficult, however, with so many problems of admitted importance brought to the notice of the Department, to keep programmes within such limits as will ensure an adequate effort being devoted to each problem that is accepted. It is essential, the Advisory Council insists, to be constantly on guard against undue dissipation of scientific effort.

Secondly, in this connexion, the Advisory Council refers once more to the need for more basic research. For ten years—during the War and since—basic research has had to be largely suspended; yet it is only on the foundation of such work that the Department's establishments can maintain, let alone increase, their ability to give the technical advice that must continue to be in such demand. In some fields, such as mechanical engineering, the Department has indeed given encouragement and financial support to new researches at universities, as at Cambridge, Edinburgh, Sheffield, Leeds, Bristol, Manchester and the Imperial College of Science and Technology and Queen Mary College, London; but apart from the natural limits to such extra-mural work, it can be no substitute for fundamental work at the Department's own stations. In current circumstances, however, the Advisory Council recognizes that a proper balance between short-term and basic work can be restored only as new staff becomes available; but it notes some improvement in recruitment during the year and a consequent limited resumption of basic work.

As regards the research associations, the choice of problem rests with their councils, including both industrialists and scientific men, as well as representatives of the Department and other government departments concerned among their members, and the Advisory Council considers that the programmes undoubtedly represent the best opinion in the various industries on the problems the solution of which can most powerfully assist their progress. That opinion might perhaps be subject to the qualification that the membership of the research association is fully representative of the industry it serves. At the same time, the Advisory Council has found some difference of opinion as to how far research associations should engage on outside laboratory research on materials and processes.

In the Council's own view, the research associations must be at liberty to take responsibility for investigations, including economic and sociological studies, in any field of science. Putting it even more generally than in last year's report, it is suggested that the research associations may, either directly or indirectly through related bodies, provide for their industries a scientific service bearing on all aspects of production that their councils may determine, including, it may be, works organization. Work of this wider nature may indeed require a type of staff difficult to find in Great Britain, and the Advisory Council fully realizes that the new ground which the research associations may be expected to cover cannot at present be large. Nevertheless, it considers that the linking of physical science and engineering with economic studies within industry holds much promise for the future, and that the training of suitable staff is a matter of importance at the present time. Manifestly, if such work is to be done at all, it must be done by co-operative effort of the type represented by the research associations.

The other main reference to the work of the research associations in the present report is in connexion with the second of the principal problems giving particular concern to the Advisory Council, namely, that of securing the quickest and fullest use of the results of research. The Advisory Council recognizes frankly that this is a complex and difficult problem; and that it is by no means as easy to ensure that the results of research conducted outside a firm's own laboratories, either in a government establishment or in a research association, are brought within the main stream of industrial activity, as it is to secure the application of the results of research undertaken by an industrial firm in its own laboratory. This is, of course, the main reason why some industrialists believe there are limits in practice to the effectiveness of co-operative industrial research in comparison with that of individual firms. The Advisory Council seems now to be fully aware of this difficulty, for while giving the closest attention to the best means of avoiding the risk that valuable results may be left high and dry in the laboratory, it points out that, as the services rendered by the establishments and the research associations are extended, the development of initiative by the individual firms must not thereby be discouraged. It is already giving close attention to one or two instances where it is not wholly satisfied that industry is being required to do all that it could.

The question how far an establishment of the Department or a research association should carry its laboratory work into the development stage does not, the Advisory Council points out, admit of a uniform answer; in its view, where the question of large-scale or pilot-plant trial arises, each proposal must be judged on its merits. Some of the facilities for full-scale tests at the Department's establishments, as at the Building Research Station or the Road Research Laboratory, or the experimental hold at the Ditton Laboratory for studies of the control of temperature and other conditions in refrigerated cargo-spaces carrying foodstuffs, are well known. Many research associations, too, have equipped themselves with large-scale facilities for special purposes. The Launderers' Research Association, for example, has an experimental laundry capable of permitting the investigation of production problems; and facilities are available in the laboratories of the Printing Research Association for carrying out all normal printing operations. The Motor Research Association is equipping a disused airfield as a proving ground for performance tests on vehicles. The textile research associations have fully equipped spinning and weaving sheds, opening and carding rooms, where new machinery and processes can be

tried out under conditions closely approximating to those of the mill; and the metal and engineering research associations are equipped for conducting full-scale investigations on furnaces, rolling-mills, foundries, gas and steam turbines and the like.

Undoubtedly, however, the determining factor in the use of science by industry is, as the Advisory Council suggests, the desire and capacity of the individual firm to apply its results, and as Sir Andrew McCance has stated, "in many of the cases where the collaboration between industries and the Association has not been so successful, it has arisen because there was an insufficient density of technically trained people in positions of control and authority". This is the cause of many of the most perplexing problems facing the Department of Scientific and Industrial Research, and although small size of a firm is not necessarily incompatible with the effective exploitation of discoveries, sometimes it is itself a symptom of the lack of scientific and technical staff rather than the cause of it. Moreover, while the work of most small firms does not call for the development of scientific discoveries, the fact that in most industries firms are at very different levels technically makes it difficult to strike the right balance in providing for the needs of both the technically advanced and those which are technically weak.

Despite all these difficulties, however, the Advisory Council is satisfied that the establishments of the Department and the research associations have a high level of achievement, and that in various ways the use of science by industry can be further promoted. As the employment of scientific men and technologists in industry spreads, much knowledge that at present has to be pushed into industry from the outside will be pulled in from the inside, with increased probability of effective use and at an earlier stage. Nevertheless, the Advisory Council is seeking more effective information on certain questions: Are firms getting the right type of science graduate? Are research reports reaching them in effective form? Do firms that are unable to maintain a research department of their own need special facilities for developing their individual ideas over and above those that can be provided by research associations? To this end, it has recommended a grant to the Manchester Joint Research Council to assist a special survey of the use of science by firms in the north-west of Britain and of the extent to which their scientific needs are being met. The Advisory Council also continues to emphasize the importance of generous encouragement of selected researches at the universities, and of adequate provision of training for young research workers.

From what has been said here, and in the article on p. 971 surveying the work of the Department of Scientific and Industrial Research, it is manifest that the various changes of personnel to which the report refers have in no way affected the continuity of policy pursued by the Council. The present report shows admirably its grasp of the principles which should determine the work of the Department, and the promotion of the utilization of science in industry.

JOSEPH HENRY: A GREAT AMERICAN

Joseph Henry, his Life and Work

By Thomas Coulson. Pp. ix+352+7 plates. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1950.) 32*s*. 6*d*. net.

THE name of Joseph Henry is known and honoured in Great Britain for his discoveries in electromagnetism, made simultaneously with those of Faraday, and his administration of the Smithsonian Institution of Washington from the time of its foundation; but very little has been written about Henry for those who wish to know more than the bare facts, and British readers, as no doubt American, are greatly indebted to Mr. T. Coulson for this excellent account of the life and work of one of the most important figures in the history of American science.

The comparison between Henry and Faraday is inevitable, not only because they worked at the same time in the same scientific field, but also because there are close similarities in their lives. Both were of humble origin and largely self-educated; both were men of strong religious convictions who yet found no difficulty, as some of their contemporaries did, in reconciling their science with their religion; and both devoted themselves, in their researches, to increasing the sum of human knowledge, leaving the application and the pecuniary gain to others.

There has been much discussion of priorities between the two. Mr. Coulson reproaches Faraday for not mentioning Henry in his early papers on electromagnetism, particularly in connexion with the ring electromagnet with which Faraday made his original discovery of the induction of electric currents on August 29, 1831; but there is really no evidence, it seems to me, that he derived the idea from Henry, or that he was even aware, at the time, of Henry's researches and improvements on Sturgeon's electromagnet. Henry's reluctance to publish has made the question a difficult one to determine; but there is no doubt, on the evidence of his paper of 1832, that he obtained induced currents by means of magnets quite independently of Faraday, and may even have done so first. There is also no doubt of his claim to the honours for the discovery of self-induction, that is, the inductive effect of a current-carrying wire upon itself. The first mention of Henry's name in Faraday's Diary is in 1838; but that was after they had met, during Henry's visit to Britain in 1837. Afterwards there are a number of references, particularly to Henry's work on secondary and tertiary induction, which greatly interested Faraday.

If we leave the somewhat fruitless discussion of priorities, it is with the recognition that Faraday and Henry were the two great pioneers in the discovery of the induction of electric currents by means of magnets, a discovery which has been fraught with almost incalculable consequences to humanity. Thereafter, Faraday extended his researches to other branches of electricity; but Henry turned to another field when he accepted the invitation to become the first secretary of the Smithsonian Institution.

The motives of James Smithson, the illegitimate son of that Sir Hugh Smithson who married the Percy heiress and became the first Duke of Northumberland, in leaving his fortune to the United States of America, a country he had never visited,

"to found at Washington . . . an establishment for the increase and diffusion of knowledge among men", provide an interesting study. We learn from this book what is of greater significance, namely, the extent to which Joseph Henry was personally responsible for preserving the Smithson fund intact and ensuring that it was devoted to its intended purpose—no mean feat in the America of his day. Henry, by his selfless and inspired administration, not only created an institution but also established a great tradition of service to the best interests of his country.

By his work for the Smithsonian, his service to the Light House Board, his share in the founding and activities of the National Academy of Sciences, and in many other ways, he became the acknowledged leader and organiser of American science. He did not escape criticism and controversy. In his earlier period he had invented the electromagnetic relay and set up the first telegraph line in his classroom at Albany; later he became involved, owing to the claims of Morse, in an acrimonious dispute regarding the invention of the telegraph. Such incidents, however, served only to throw into relief the extent and importance of his scientific achievements. His independence of mind and integrity of character were evident in his relations with President Lincoln and many other prominent Americans, with Wheatstone, Faraday and a host of scientific colleagues and friends; and in the recounting of these personal contacts, for example, that of Henry with the young Alexander Graham Bell, the character of a great man stands out from the pages before us.

THOMAS MARTIN

TEXT-BOOK OF MEDICAL PROTOZOOLOGY

Handbook of Medical Protozoology

For Medical Men, Parasitologists and Zoologists. By Dr. Cecil A. Hoare. Pp. xv+334. (London: Baillière, Tindall and Cox, 1949.) 35*s*. net.

THE segregation of tropical medicine from general medical training is, as the author points out, purely artificial—particularly under modern conditions of rapid air-transport and closer association between the tropics and temperate climates. Nevertheless, in British schools of medical training the study of the Protozoa and of the diseases caused by them is divorced from the general medical curriculum and assigned to the domain of tropical medicine, as a postgraduate study. As a result, the medical student and the general practitioner in Great Britain have only a superficial acquaintance with the Protozoa parasitic in man, and have to turn to text-books to acquire at second hand the necessary information; and for lack of a suitable single text-book written in English and dealing only with medical protozoology, they have to acquire this information from text-books on tropical medicine, on parasitology, or on protozoology in general, such as that great classic which also emanated from the Wellcome Laboratories, "Wenyon's Protozoology".

The author tells us that he wrote this book in order to satisfy the demand for a short text-book devoted exclusively to medical protozoology and suitable for use not only by the general practitioner, but also by the more specialized clinical pathologist, parasitologist and laboratory worker. Dr. C. A. Hoare has admirably fulfilled his obligations, and, in addition, every teacher and research worker in tropical medicine will be grateful to him for having supplied them with an up-to-date, authoritative and concise work of reference.

The subject-matter of Dr. Hoare's book is divided into three parts, which deal with the Protozoa found in man from the general, the systematic and the diagnostic aspects; and in a work of such considerable importance it appears appropriate to consider these divisions separately. Part 1, which represents about one-quarter of the book and which is divided into three chapters, gives a general account of the Protozoa. The first chapter deals with their status, structure, reproduction and physiology, and it is pointed out that since the function of plants is perpetual synthesis, and that of animals is analysis, the spirochætes which synthesize their food supply fall into the former category and should be omitted from books on protozoology. The second chapter describes the rules governing nomenclature and the principles used in classifying the Protozoa. In this connexion it is of interest to note that *Dientamœba fragilis* is placed among the "flagellates of uncertain position"; but owing to its amœboid phase, its morphology and life-cycle are considered along with the members of the Rhizopoda.

The third chapter, which describes the ecology of the Protozoa, is one of the most interesting in the book, and the author's wide knowledge of the free-living, as well as of the parasitic Protozoa, has enabled him to write an illuminating and helpful account of the inter-relationship existing between man and this vast group of organisms. When considering the definition of the term "host", the author refers to the lack of agreement concerning what constitutes the "intermediate host" and what the "final host", and, in order to avoid confusion, arbitrarily adopts the term "intermediate host" as being applicable only to the vector. The problem of "host-restriction"—the author very rightly prefers this term to host-specificity—is dealt with in some detail, and the account shows clearly how with increasing knowledge most of the so-called "pathogenic protozoa of man" have been proved to parasitize also many non-human mammalian hosts. There follows an interesting general account of the anatomical localization and of the tissue specificity of parasitic Protozoa, the description of the behaviour of individual species being considered later in the book. The vexed question of biological races, a subject on which the author is a recognized authority, is briefly but adequately dealt with. The succeeding nine pages are allotted to infection and resistance, and to the general aspects of protective vaccination. In this connexion it is pointed out that protozoology lags behind bacteriology, and at the present time surprisingly little is known concerning how certain parasitic Protozoa produce their pathogenic effects, and that we are still very ignorant of the nature of the tolerance, resistance or immunity which, in certain instances, is developed against their attacks.

The author refers, albeit very cautiously, to the possible production of toxins; but there seems little evidence of production of toxins by the malaria parasite or by the pathogenic trypanosomes, leishmaniasi and entamœbæ. Under vaccination the author states (p. 58): "The only protozoal disease in which vaccination is effective is cutaneous leish-

maniasis, whereas in other protozoal diseases all attempts at immunization have been unsuccessful". Presumably this statement refers to the practice adopted by the natives in the East of inoculating themselves with *Leishmania* on the arm or leg to prevent the possible acquirement of a disfiguring sore on the face; if so, such a practice can scarcely be considered as a method of preventive vaccination, since the course of the disease is not in any way modified, and it is only the site of the initial papule that is affected. The treatment of the protozoal diseases is omitted, as being outside the scope of the work; but there is an excellent summary of the principles of chemotherapy as applied to the Protozoa, in which attention is directed to the importance of the development of drug-fastness especially in trypanosomiasis. In a new edition (for it seems highly probable that this excellent work will demand a new edition), it would be worth while directing attention to the persistence of drug fastness through the insect vector, and to the important implications involved.

The account of the ecology of the Protozoa concludes with a description of the geographical distribution of the diseases they produce. For this purpose the author has brought together and summarized a mass of facts, previously widely distributed throughout the literature, concerning such important diseases as malaria, amœbiasis, trypanosomiasis and leishmaniasis, and he has shown how the establishment and spread of these diseases is influenced by such diverse factors as climate; the cultural level, habits, nutritional requirements and movements of the human population; the presence, density and habits of the insect vector; the presence, nature and abundance of animal reservoirs of the disease; and, finally, the effects of the introduction of new strains, a factor which has become increasingly important under modern conditions of widespread and rapid air-transport.

Part 2, which contains some two hundred pages and which is the longest of the three parts, is devoted to a systematic account, not only of the pathogenic Protozoa parasitizing man, but also of the more common commensal Protozoa occurring in the gut and of certain coprozoic Protozoa, the appearance of which in the fæces may mislead the novice. In addition, certain important species of trypanosomes common in animals, although not normally occurring in man, are described. In each case the account given of a particular species includes relevant information under such headings as synonyms, relation to disease, geographical distribution, morphology and life-history (including nutrition), reproduction, races, atypical forms, cultivation, host–parasite relationship, pathogenesis, immunity, incidence, infection in lower animals, transmission, viability and diagnosis. These headings are taken from the account of *E. histolytica*, and naturally less important parasites are not so fully considered; but in every instance there is a clear and adequate account which in the majority of cases could only be duplicated by a prolonged search through literature. These descriptions are not a mere compilation of facts, but are critical summaries of those views with which the author finds himself in agreement. Such a method of treatment is—to quote the author—"frankly didactic and somewhat dogmatic, which is unavoidable if the student is not to be confused with conflictory data and conceptions which he is not in a position to verify himself". The author has selected his authoritative statements with care, and it is doubtful if teachers of medical protozoology will differ from him except on points of minor importance.

Part 3 is an excellent account of the more important diagnostic methods which may be employed in the recognition of protozoal infections, in the making of permanent preparations and in the cultivation of the human entamœbæ and hæmoflagellates. The book concludes with a description of how mosquitoes, sand flies, tsetse flies and reduviid bugs should be dissected and examined for the presence of parasites transmissible to man.

A short bibliography and an adequate index—a very important feature in a work of this nature—are provided. There is a laudable absence of printer's errors; I have noticed only one significant misprint, "$\frac{1}{2}$ in oil immersion" in error for "1/12 oil immersion" (p. 273). The illustrations, many of which are from original drawings by the author, are excellent and there are three fine colour-plates executed by Mr. B. Jobling, whose work is known to all students of protozoology. The price of modern text-books is high; but in view of the excellence of the subject-matter and the fine standard achieved by the publishers, the price of 35*s.* is more than reasonable.

R. M. Gordon

NEW DEVELOPMENTS IN PIEZO-ELECTRIC CRYSTALS

Piezoelectric Crystals and their Application to Ultrasonics

By Dr. Warren P. Mason. (Bell Telephone Laboratories Series.) Pp. xi+508. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1950.) 56*s.* net.

During recent years the research on piezo-electric crystals has extended from quartz and Rochelle salt to cover many new water-soluble synthetic materials. Dr. W. P. Mason has contributed a large part to the new development and has compiled a lucidly written book based mainly on published and unpublished investigations of the Bell Telephone Laboratories. The emphasis in this book centres on the presentation of new results rather than on known subjects, but for completeness the properties and applications of quartz and Rochelle salt are included.

The first chapters are written in the form of a general introduction to piezo-electricity and contain —besides a survey of crystal systems, classes and symmetries—the elastic, piezo-electric and dielectric relations in crystals, given in tensor notation. The extent of the search for new materials can be seen from the chapter entitled "Properties of Crystals Determinable from Small Sizes", which contains a list of nearly two hundred crystals classified into four groups according to their coupling-strength. The thorough investigation culminated in the discovery of ethylene diamine tartrate and the useful properties of dipotassium tartrate, which are replacing quartz crystals in electrical filters. These materials have been treated in a separate chapter. The properties of ammonium dihydrogen phosphate and potassium dihydrogen phosphate, a new ferro-electric type of crystal, are also discussed in detail.

A chapter is devoted to information based on new measurements on a number of piezo-electric crystals belonging to different symmetry classes. The con-

siderable theoretical progress made in the past few years in analysing the properties of ferro-electric types of crystals and in locating the causes of the ferro-electric anomalies in Rochelle salt, potassium dihydrogen phosphate and barium titanate is clearly presented. Dr. Mason also discusses the electrostrictive effect in Rochelle salt and barium titanate, and presents data on the behaviour of these new ceramics as electro-acoustic transducer elements. Applications of ultrasonics for the measurements of the physical properties of gases, liquids and solids are given in the remaining part of the book, which contains much new information. The application of tensor calculus to the equations of liquids, gases and solids is included in an appendix.

This book is not written as a text-book but as a report of the comprehensive work carried out in the Bell Telephone Laboratories during the past few years. It should appeal not only to the crystal technologist and physicist but also to the crystallographer and chemist. Dr. Mason states that "the book can be regarded as an introduction to the study of piezo-electricity"; he is a very modest man.

R. Bechmann

FRACTIONAL DISTILLATION IN THE LABORATORY

Laboratory Fractional Distillation

By Thomas P. Carney. Pp. ix+259. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1949.) 42*s*. net.

MANY organic chemists having no great background of physicochemical knowledge, and little facility in even elementary mathematics, have during the past ten years become aware that the technique of fractional distillation, perhaps the most ancient art of the organic laboratory, is in process of a rapid improvement that cannot be ignored. Nevertheless, to do no more than pick from the mass of published papers the few worthy of closer study has not seemed easy.

The declared purpose of the author of this book is to bring to the research worker and to the student an up-to-date and practical knowledge of the art of fractional distillation. It may be agreed that this purpose is in large measure fulfilled for those readers in the United States for whom the book was written in the first instance. British readers will find that this book has a number of shortcomings.

The twenty-two chapters deal with most of the aspects of the subject which one would expect to find treated. Space has been found for a good deal of matter which is not now of great practical importance, and there are many figures of obsolete equipment that could well be dispensed with. The author's reluctance to use more than the irreducible minimum of mathematical development in his treatment of column operation, while understandable, does lead to difficulties of exposition. It is a pity that space could not be found for adequate deductions of the Rayleigh equation and the Fenske equation, from first principles.

There are occasional obscurities of language, for example, on p. 18, and some statements which are quite misleading, as on pp. 28 and 105. The British reader will be surprised to find no mention of the Dixon packing, which is certainly one of the most effective and is in wide use. A rather odd feature of the bibliographical apparatus is that reference is not made to a number of standard text- and hand-books which give ampler treatment to many rather important distillation topics that Carney treats cavalierly or not at all; while, on the other hand, a large proportion of papers cited in the general bibliography in no way supplement textual material.

There is much in this work that could be read with profit by any chemist who feels deficient in knowledge of the possibilities and limitations of fractional distillation. Some readers will think it could have been a shorter, better and cheaper book.

E. A. Coulson

THE SUGARS

Structural Carbohydrate Chemistry

By Dr. E. G. V. Percival. Pp. viii+246. (London: Frederick Muller, Ltd., 1950.) 25*s*. net.

THIS volume contains a readable account of modern views on carbohydrate chemistry and is well illustrated. Within recent years considerable advances in technique and in the interpretation of the structure and reactions of mono- and polysaccharides have been made; the more important of these advances are described in this book. The subject has been developed in a logical manner; the first chapter deals with the general properties and configurations of the monosaccharides. For the student to possess a satisfactory knowledge of carbohydrate chemistry it is essential that he should be familiar with the configuration of the different sugars and with the changes which occur when pyranose and furanose rings are formed. The first two chapters deal with these problems in an exceptionally lucid manner. The next two chapters describe the characteristic reaction of the sugars. The important reaction leading to the formation of sugar anhydrides is described in some detail, together with their conversion into amino sugars of known constitution. Then follow chapters on the structure of oligosaccharides and polysaccharides.

Since Dr. E. G. V. Percival, a pupil of the late Sir Norman Haworth, was among the first to determine the structure of a polysaccharide by the classical methylation procedure, it is no surprise to find that his experience has been embodied in these chapters, and that he has given an excellent account of the problems involved. Chapter 8 describes the preparation, reactions and occurrence of the uronic acids. This chapter contains a very useful account of the chromatographic separation of sugars and their derivatives by adsorption and partition procedures. This is the first time a detailed account of this technique has appeared in a text-book of carbohydrate chemistry.

The last three chapters deal with the chemistry of the glycosides and of other important sugar derivatives, and with the chemistry of some of the rarer polysaccharides. In particular, a very useful account of inositol and its derivatives is included. The reviewer considers that a little more emphasis might have been placed on the use of atomic models, especially in connexion with the reading of the first two chapters.

This book should be in the hands of all honours students and on every library shelf. The large number of references it contains makes it invaluable.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT FOR 1948-49

THE annual report of the Department of Scientific and Industrial Research for the year 1948–49* includes the report of the Committee of the Privy Council, over the signature of the Lord President of the Council, that of the Advisory Council, over the signature of Sir Ian Heilbron, and the summary of work. If anything, the one hundred and fifty or so pages of the report occupied by this summary, ninety-five of which are concerned with the work of the research associations, give an even more impressive picture of the contribution which science is making to the national welfare in every department of life, social as well as industrial, than was given by the pre-war reports. The accounts of work are naturally less detailed than those given in the reports from the individual boards or institutions published separately, but the composite picture makes the report a reference book the value of which is enhanced by the details of the assessors and members of research boards and committees, the lists of establishments and research associations and of publications issued during the year which are included among the appendixes.

Of the net expenditure of £3,273,109, annual grants to research associations amounting to £959,625 represent the largest single item, besides which special grants amounted to £59,317. Expenditure on the National Physical Laboratory was £689,528, against which £253,311 was received for work done for various boards and committees. Net expenditure on building research was £233,179, on road research £214,676, on fuel research £147,405, on food investigation £141,135, on forest products research £84,710, on radio research £51,798, on water pollution £39,773, on pest infestation £33,571 and on mechanical engineering £17,972. Of the gross expenditure of £101,260 on the Chemical Research Laboratory, £39,584 was covered by receipts; receipts amounting to £18,308 covered more than half the gross expenditure of £36,002 on fire research projects. Net expenditure on hydraulics was £8,501 and on the Geological Survey and Museum £142,728 (gross expenditure on the latter, £167,687). Net expenditure on headquarters administration was £79,237, on headquarters intelligence £32,109, and on headquarters overseas liaison £31,483. Research contracts accounted for £45,450 and grants for special researches for £268,379.

Grants to students, etc., amounted to £160,598, and in a further appendix details are given of these grants in comparison with previous years. Of the 736 grants to students-in-training, compared with 498 in 1947–48, 270 were in chemistry, 283 in physics, 61 in biology, 43 in engineering, 40 in metallurgy, 20 in geology and mineralogy, and 19 in mathematics and astronomy. Of the twenty-three senior research awards (compared with twenty-five in 1947–48), twelve were in chemistry, six in physics, two in mathematics and astronomy and one each in biology, metallurgy and engineering. Grants for special investigations numbered 99 as against 83 in 1947–48 and were distributed as follows: 48 in physics, 21 in chemistry, 11 in engineering, 10 in biology, 7 in mathematics and astronomy, and 2 in geology and mineralogy.

* Department of Scientific and Industrial Research. Report for the Year 1948–49. (Cmd. 8045.) Pp. 260. (London: H.M. Stationery Office, 1950.) 5s. 6d. net.

From the summary of work it is possible to do no more than select examples to illustrate the manifold ways in which the work of the Department contributes both to national welfare and industrial efficiency. In the clay areas of the south of England widespread damage to dwelling-houses has been caused by seasonal movements accompanying the drying shrinkage of the clay beneath the foundations. Detailed study of this problem by the Building Research Station has pointed to the need for placing foundations on shrinkable clays at a depth of at least three feet below ground-level and the importance of not planting fast-growing trees near the houses. The Building Research Station has also studied the parallel problem of damage to industrial structures such as brick kilns, boilers, etc., caused by the drying shrinkage of clay due to penetration of the heat used in the industrial process. A new kiln built to a design incorporating a series of transverse parallel arches in the foundation has given a small rise in temperature of the foundation soil after a year of service, indicating that the system is satisfactory. Considerable attention has also been given to floor surfacing materials, while a systematic large-scale study of the properties of bricks from the many sources in Great Britain has been completed for the National Brick Advisory Council. Besides work on the structures and strength of materials and on the efficiency of buildings, a branch laboratory of the Station has been opened at Thorntonhall, near Glasgow, to provide, besides information services and facilities for investigation, an exposure site for duplicating tests on building materials under different weather conditions.

Of the work of the Chemical Research Laboratory, that which aims at the husbanding of material resources, particularly key materials, such as metals, and the work on metallic corrosion deserve mention here, as well as that on the utilization of indigenous raw materials, such as the extraction of gallium from flue dust and the separation and utilization of tar constituents, and the investigation of potentially interesting new processes and materials, like high polymers and plastics. Of high industrial importance also are the researches leading to fundamental reference data, or which develop new methods and techniques. Among the results obtained, the field of fire research may be mentioned; work here has included studies of fires in inflammable liquids, the development of a smaller apparatus for determining the 'figure of merit' for foam compounds, the development of an improved helmet for firemen and investigation of the fire risks of the gravity warm-air system in modern buildings, and of the behaviour of water-spray extinction systems.

Food research has included the improvement of the quality of frozen meat imported from the southern hemisphere, the collection of whale meat for human consumption and fundamental research into the behaviour and properties of whale meat. The poor condition in which most of the 'white' fish catch is at present landed is under investigation at the Torry Research Station, Aberdeen, where a fresh assessment of the possibilities of freezing at sea is under way. Special attention has been given to the preservation of eggs by oiling, while work at the Ditton Labora-

tory, near Maidstone, has demonstrated that there are a number of English varieties of dessert apples, besides Cox's Orange Pippins, which might be grown commercially on a large scale in Britain and have the requisite storage properties to enable the home market to be supplied with dessert apples for a much longer period than at present. The feasibility of storing potatoes in warehouses, instead of in clamps, has been demonstrated, and methods for improving the quality of broccoli reaching the consumer have been indicated. Fundamental work at the Low Temperature Research Station, Cambridge, has established a striking correlation between the ascorbic acid concentration and the concentration of sucrose in potato tubers, while ascorbic acid has also been shown to vary in cress seedlings with the nature of the medium in which the seedlings are grown.

The chief large-scale project in the Forest Products Research Laboratory is the continuing series of tests upon Colonial timbers, particularly upon those of West Africa and British Guiana, aimed at finding means of replacing timbers traditionally obtained from 'hard currency' areas and finding substitutes for specialized timbers now scarce. The Physics Section has studied further the fundamental constants of timber and its constituents, and reports have been issued on the natural durability of timber and the preservation of mine timbers. At the Fuel Research Station research work on domestic heating has been advanced as rapidly as staff and equipment permitted, and a calorimeter building has been constructed containing four 'cabinets', about the size of ordinary living-rooms, in which various types of domestic heating appliances can be examined. Other work has been concerned with the complete gasification of low-grade fuel, underground gasification of coal, smoke elimination and increasing the availability of water-tube boilers for continuous steaming. The Geological Survey and Museum has touched on such important matters as water supplies and the exploration of radioactive mineral deposits. Although the Hydraulics Research Station has still to be set up, under the Hydraulics Research Board major studies with the aid of scale models have been made of the River Forth, Rosyth Dockyard, and of the training works required to keep the deep-water channel in the Wyre estuary alongside the proposed wharf at Burn Naze and to maintain a navigable channel between Burn Naze and the sea.

When the Mechanical Engineering Research Organization is fully developed at East Kilbride, the laboratories will have a staff of six hundred, including a hundred scientific officers organized in seven research divisions, covering the properties and strength of materials; mechanics of solids, stress analysis and vibration; mechanics of fluids, including hydraulic machinery; lubrication, wear and corrosion; mechanisms and engineering metrology; mechanics of formation and machine shaping of materials; heat transfer and applied thermodynamics. Research on size effect in fatigue, complex stresses at high temperatures and the strength of screw threads is already being carried out for the Board at the National Physical Laboratory, and the Board has also given encouragement and financial support to a number of new researches at universities. Among other work at the National Physical Laboratory may be mentioned the investigations on the aerodynamic properties of suspension bridges, with particular reference to the proposed bridge over the River Severn, on the provision of a radio service of standard frequency transmissions, on quantitative criteria of the definition of optical instruments, on the development of methods for producing test objects of accurately specified contrasts with the view of meeting the needs of photographic lens manufacturers for resolution tests at low contrast, on the metallurgical problems associated with the production of useful power from atomic energy, on engineering standards, on ship design and on a new design of ion source for the mass spectrometer.

Outstanding features of the work of the Pest Infestation Laboratory during the year were the large-scale experiments with methyl bromide, which have indicated that completely effective fumigation of silo bins full of grain can be obtained by circulating the fumigant through the grain by means of suitable equipment. Measurements of the toxicity to insects of DDT smokes and of the films of DDT formed by deposition of the smoke on building surfaces showed that deposits on the floor were twenty times as heavy as on the walls and ceiling, and contained about 66 per cent by weight of DDT against 12 per cent. A patent has been taken out for a type of packing which has so far shown itself to be proof against insect penetration, while good progress has been made in dealing with the problem of blowflies in slaughter-houses.

A major part of the programme of the Radio Research Board is concerned with the study in all its aspects of the propagation of electromagnetic waves under the conditions met with in practice and over the entire radio-frequency spectrum now available. The study of the characteristics of the ionosphere at high frequencies has continued, as well as of the propagation of very short radio waves through the lower atmosphere and the problem of atmospheric noise arising from thunderstorms or other disturbed meteorological conditions. The post-war work of the Road Research Laboratory on road materials and methods of road construction shows clear trends to an increasing study of road-making plant and machinery of all kinds; this includes a more intense study of road maintenance problems, chiefly in the direction of increasing the life of sprayed surface dressings and their bituminous carpet coats, and the development, by full-scale experiments, of the most economical form of surfacing for the prevailing traffic and soil conditions in any locality, and the best use of locally available materials. A special joint committee has been formed with the Ministry of Supply to study soil problems, notably those concerned with the negotiation of bad ground by military vehicles, the provision of emergency airfields in forward areas and the construction of military roads by soil stabilization. Road safety investigations have dealt with the problem of dazzle, the testing of brakes and pedestrian crossings. Water pollution research has related to the treatment of sewage, the control of filter-flies and the repeated use of sea-water for cleansing shell-fish, as well as the treatment of industrial waste-waters.

Space does not permit citing further examples of the interests of the Department, from the work of the forty research associations, some of which are making their own independent contributions in fields from which illustrations have already been given. In the field of food research, for example, the British Baking Industries, the British Flour-Millers and the British Food Manufacturing Industries Research Associations are carrying out highly important work. Some of the research associations are now

operating on a considerable scale; the British Iron and Steel Research Association last year had an income of £368,189, while the British Coal Utilization Research Association, the British Cotton Industry Research Association, the British Electrical and Allied Industries Research Association and the British Shipbuilding Research Association all had incomes exceeding £200,000. Besides these, however, only the British Rayon Research Association (£187,501), the Wool Industries Research Association (£121,907), the Motor Industry Research Association (£108,720), the British Ceramic Research Association (£114,530), and the Parsons and Marine Engineering Turbine Research and Development Association (£104,058) had incomes of more than £100,000. Beyond this no more can be said than that the accounts of the work of the research associations are admirably written, and present a most convincing picture of the value of their contribution to industrial efficiency and national welfare.

The Department is to be congratulated on a report which fully maintains, if indeed it does not surpass, the standard of the pre-war reports; and it is welcome news that the Advisory Council has made arrangements that will enable future reports to be presented within a few weeks of the end of the year to which they relate.

ELECTRON MICROSCOPE OBSERVATIONS ON THE SPERMATOZOID OF *FUCUS*

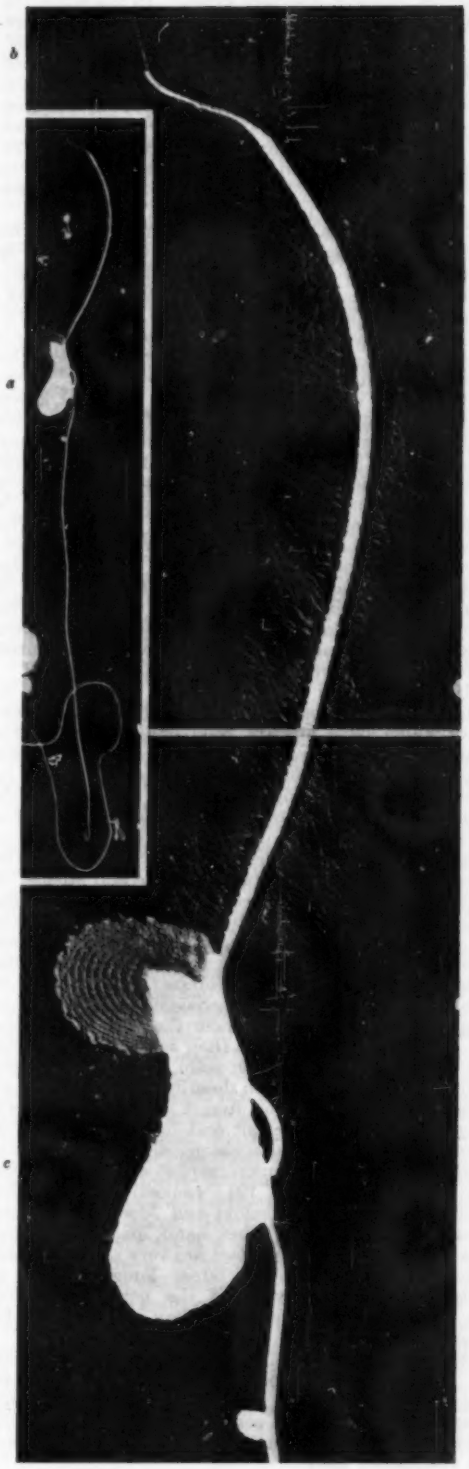
By Prof. IRENE MANTON and B. CLARKE
University of Leeds

THE brown seaweed, *Fucus serratus*, is such a familiar object both on the shore and in class rooms that a preliminary note on the structure of its spermatozoid as revealed by the electron microscope may not be out of place.

The accompanying micrographs have been taken with the new Philips's electron microscope, recently installed in the Botany Department of the University of Leeds with the aid of a grant from the Department of Scientific and Industrial Research. The material had been killed with osmic vapour when swimming very vigorously and was preserved in formalin diluted with sea water. Before mounting it was washed in distilled water, then dried on a 'Formvar' film and shadowed with uranium. A single complete spermatozoid is shown in Fig. *a*, with enlarged detail of the body and front end in Figs. *b* and *c*.

As regards the body (*a* and *c*), this is shrunken and somewhat distorted by the drying. Its internal structure cannot be investigated in this particular specimen, though most of the gross features of its general shape are significant.

The membranous appendage with the 'thumb-mark' pattern (*c*) is one of the most interesting of these features. Its presence, though not the details of its shape and markings, can be readily demonstrated with the light microscope if fresh spermatozoids are killed with osmic vapour and examined at once. It can then be seen as a transparent beak-like organ curving away from the base of the flagellum at the front end of the body. This attitude is, how-



Electron micrographs (at 80 kV.) of a spermatozoid of *Fucus serratus*, shadow-cast with uranium: *a*, a complete cell (× 3,200); *b* and *c*, consecutive portions of the front end of the same specimen (× 16,000)

ever, the effect of chemical killing. In life when the cell is swimming freely the front end has the shape of a very elongated, tapering and mobile snout, suggesting that the membrane is perhaps wrapped round the base of the flagellum and moving in unison with it. If, however, the front flagellum becomes entangled with an obstacle so that forward movement is checked and the alignment of parts disturbed, the membrane can be seen as a separate organ as in *a*, even in the living cell. The functional significance of the organ is at present unknown.

The two flagella, seen complete in *a*, can also be seen with the light microscope if their motion is slowed down or if the cells are killed. The hairy appendages on the front flagellum are, however, completely invisible except with the electron microscope, and they appear to constitute a definite morphological feature by which, in this species, the front flagellum differs from the hinder one. These hairs can be demonstrated in fresh material killed with osmic vapour directly on the 'Formvar' carrier and dried down at once. Under this treatment they are, however, very liable to fragment or fall off, and some hours hardening in formalin between the killing of the cells and mounting them for observation is undoubtedly conducive to better pictures. The functional significance of the hairs is unknown, though it is not difficult to obtain indications, by watching the live spermatozoids, that the actions of the front and hind flagella are not the same. The very long hind flagellum in our experience is always smooth; but much further work will be required before the mode of action of either is understood.

It is premature to discuss these observations in detail or to attempt to enumerate all the other new facts which have already been obtained from this material. It is, however, perhaps desirable to point out that hairy flagella have been described before in other organisms, though mostly on evidence which has been open to doubt[8]. The first description of a "Flimmergeissel", as opposed to the smooth or "Peitschgeissel", appears to have been that of Fischer[1] in 1894, working with *Euglena* and *Monas*. A "Flimmergeissel" was, however, not only seen but also excellently photographed by Loeffler[2] in 1881, again in a flagellate of the *Monas* type, using his own recently invented method for staining bacterial cilia. The hairs composing the "Flimmer" are, indeed, of the same order of size as bacterial cilia and, like them, can only be made visible under the light microscope by methods which increase their width, for example, by the use of an apposition stain. By similar means "Flimmer" has since been described in other euglenoids[3], in some aquatic fungi[4], in certain brown flagellates (Chrysophyceæ)[5] and in the zoospores of some of the Heterokontæ among algæ[6]. Two rather early sets of electron micrographs[7] are known to us, published in 1945 and 1947 respectively, in which "Flimmer" of the Euglenoid and *Monas* types can just be seen. On the other hand, papers claiming that "Flimmer" is an artefact are very numerous and are still appearing[8]: the latest known to us is dated 1949, but in view of the new observation on *Fucus* this last contention may perhaps now be finally allayed.

We are not aware of any previous demonstration of "Flimmer" in the brown algæ as such; but our experience already suggests to us that this character may be found to have considerable phyletic as well as functional interest now that the details of it can be adequately seen.

This work is being continued and will be published in greater detail elsewhere.

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HEAT FLOW IN THE EARTH

At a meeting of the British Association, Section A (Mathematics and Physics), on September 4, 1950, at Birmingham, problems concerning the heat flow in the earth were discussed. The Astronomer Royal was in the chair.

Prof. H. Jeffreys spoke on "Potassium and the Earth's Thermal State". He said that though the heat output of the radioactive decay of the rare isotope of potassium (K^{40}) in the earth's crust is now smaller than that of the uranium and thorium series, it had been recognized that it might have been much greater in the earth's early history. There are two decay schemes of potassium-40 with different decay constants λ_β and λ_ε:

(1) $K^{40} \rightarrow Ca^{40} + \beta$; decay constant $= \lambda_\beta$.
(2) $K^{40} + \beta \rightarrow A^{40}$; decay constant $= \lambda_\varepsilon$.

The determination of λ_ε (Ahrens and Evans[1]) was accomplished by the measurement of the amounts of potassium and calcium in specimens of lepidolite of known ages (t), which will enable λ_ε and λ_β to be calculated from the following equations:

$$Ca^{40} = 0{\cdot}000109\,\frac{\lambda_\beta}{\lambda}(\exp \lambda t - 1)\,K + a, \text{ where } \lambda = \lambda_\varepsilon + \lambda_\beta,$$

and

$$A^{40} = 0{\cdot}000109\,\frac{\lambda_\varepsilon}{\lambda}\,(\exp \lambda t - 1)\,K.$$

Using $\lambda_\beta = (0{\cdot}51 \pm 0{\cdot}04)/10^9$ years, which is known to be reliable, $\lambda_\varepsilon = (1{\cdot}91 \pm 0{\cdot}16)/10^9$ years.

This seems likely to be an over-estimate, because of the initial calcium-40, for Prof. A. O. Nier (private communication) has calculated from the relative abundance ratios of calcium-40 and -44 the radiogenic fraction of calcium-40 in the oldest lepidolites. This works out to be only 0·2 parts in 10,000, whereas for $\lambda = 1{\cdot}91/10^9$ years this ratio would be 0·8 parts in 10,000.

On the other hand, λ must be greater than $0{\cdot}87/10^9$ years, for λ_ε, as determined from the argon, some of which may have escaped, in potassium chloride of age 3×10^9 years is $0{\cdot}36/10^9$ years.

Suess and Poole[2] have calculated the argon generated by the disintegration of potassium in the granitic layer. With $\lambda = 1{\cdot}91/10^9$ years, this would work out at 214 gm./cm.^{2} in $2{\cdot}1 \times 10^9$ years (the minimum age of the crust) and 2,200 gm./cm.^{2} in $3{\cdot}3 \times 10^9$ years (Holmes's estimate). The actual argon in the atmosphere per unit area of the earth's surface is 13 gm./cm.^{2}, and as one-tenth of the granitic layer has been denuded this value of λ could be reconciled only with the minimum age of the crust.

Later experimenters[4] find that the β-rays have a continuous distribution of energy with a mean of (0·5 ± 0·1) MeV., giving a heat generation of

(13·4 ± 2·9) MeV./sec./gm. potassium or (1·60 ± 0·35) × 10^{-6} cal./gm. potassium per year. Ahrens and Evans[1] and Graf and Gleditsch[2] give the γ-ray energy as (1·5 ± 0·5) MeV., so that the total heat output is (2·26 ± 0·36) 10^{-6} cal./gm. potassium per year (cf. Bullard's value[3]), which is much less than the output by uranium and thorium.

In the theory of the earth's thermal state it is necessary to compute the limiting temperature S_0 at the base of the radioactive layer after a long time, changes of radioactivity being ignored. The contribution of potassium to S_0 (revising Bullard's work[3]) is 120°, and its contribution will change with time as $\exp \lambda T$. As S_0 on these data works out as 880°, the temperature of the interior would be above the melting point T_m when $\exp \lambda T_m$ is 7, that is, at times less than Holmes's estimate of the age of the crust (see table).

λ	T_m
$1 \cdot 9/10^9$ years	1×10^9 years
$(1 \cdot 43 \pm 0 \cdot 26)/10^9$ years	$1 \cdot 4 \pm 0 \cdot 3 \times 10^9$ years

However, if an initial fluid state is supposed, solidification in the mantle would begin from the bottom upwards, and when complete, fractional crystallization would take place. As is indicated by the observed separation of materials at the surface, the residual liquid between the grains would be squeezed upwards, taking with it the radioactive constituents until their concentration at the surface allowed S_0 to drop and solidification occurred everywhere.

It appears, accordingly, that S_0 could not be above the melting point after a solid crust was formed; and that if a theory leads to the opposite result it must have assumed either too great an age or too great an average depth of the radioactive constituents (since S_0 contains this average depth as a factor).

Dr. S. K. Runcorn spoke on "The Geomagnetic Secular Change and Thermal Convection in the Earth's Core". He said that the discovery, by seismologists, that the earth's core, 3,500 km. in radius, is a liquid of viscosity less than 10^6 poise, has proved to be the essential clue in the interpretation of the geomagnetic secular change. For it is only by postulating fluid motions in the core that the paradox between the rapid change in the geomagnetic field, in certain places reaching 50 per cent in a hundred years, and the time-scale of geological phenomena can be explained. In particular, the remarkable westerly drift of the points of maximum annual change (the isoporic foci), noticed in older data by Van Bemmelen[6] and Bauer[7] and rediscovered by Vestine[8] in his survey of the geomagnetic field between 1905 and 1945, cannot be explained except by fluid motions in the core, the magnitude of which are thus found to be 0·05–0·1 cm./sec. The absence of any north–south component of the velocity of the isoporic foci can be shown to be a direct consequence of the predominance, for motions of this magnitude, of the Coriolis term in the hydrodynamical equations of the core.

Bullard[9,10] and Elsasser[11] have discussed possible causes of the motions in the core and have come to the conclusion that astronomical causes are not sufficient and that thermal convection must be postulated.

Bullard supposes that a small concentration of radioactive material (about 5·5 times that found in iron meteorites) is present in the liquid core, generating a total of 5×10^{12} cal./sec. This he shows will maintain a temperature gradient equal to the adiabatic one (1·1° C./km.), despite the flow of heat through the surface of the core under this temperature gradient ($3 \cdot 4 \times 10^{-6}$ cal./cm.^{2} sec., as the thermal conductivity* is calculated to be 0·31 cal./cm. deg. C.). An amount of heat must be removed from the mantle equal to the amount generated if the adiabatic gradient is to be maintained. The temperature gradient in the mantle will be that given by the change of the melting point of the basic silicates with pressure, which equals 3° C./km. near the surface of the earth. The thermal conductivity of the basic silicates is about 5×10^{-3} cal./cm. sec. deg. C., so that the heat carried away through the mantle is $0 \cdot 15 \times 10^{-6}$ cal./cm.^{2} sec. Though the constants on which these figures are calculated are not known with accuracy, it appears that unless slow convective motions are occurring in the mantle this convection model is untenable.

Elsasser suggests an alternative model in which he supposes that the core is effectively thermally insulated, but that certain of the heavy oxides of uranium and thorium found their way to the solid central body within the core, just as the concentration of the radioactive compounds in a thin shell of the mantle is presumably due to the fact that the halides of uranium and thorium are gaseous. He shows that, supposing the radioactive content of the central body per unit surface area is about five per cent of that of the crust, $1 \cdot 1 \times 10^{-6}$ cal./cm.^{2} sec. will be generated, which exceeds the heat conducted away from the central body through the core under the adiabatic temperature gradient. Thus convection is maintained; the liquid core heating up through about 300° C. during the life-time of the earth.

Dr. P. L. Willmore pointed out that the latter view is not compatible with the generally accepted view of a cooling earth.

Dr. G. M. Lees said that before the impact of geophysical speculation on geological processes, geologists had attributed the zones of compression, which formed fold and thrust mountain ranges, to the effects of shrinkage of the earth's core, and a slow cooling had appeared to supply an adequate mechanism. The discovery of radioactivity, indicating the continuous development of new heat, upset this simple conception and released a tide of new ideas. Various forms of giant, deep-seated convection currents, continental drift, permanence of oceans, and isostasy, had been invoked in the search for an adequate mechanism to explain observed facts, but a satisfactory solution has eluded us so far. Recent speculations on the inner shells and core of the earth by Ramsey, based on Bridgman's high-pressure researches, show that there are many factors which had not been appreciated earlier, and Dr. Lees asked whether the review of all aspects of the outward flow of earth heat would allow geologists to revert to their original conception of a shrinking earth.

Prof. Jeffreys, in reply, said that the thermal contraction of the earth gave an answer of the right order of magnitude to the problem of the cause of mountain building. If the problem of a uniformly cooling body is solved for the case of radial symmetry, it is found that the frequency of mountain building should not decrease with time, which agrees with the evidence but is not the conclusion of the earlier

* In this calculation the electrical conductivity of the core is taken as 5,000 ohm^{-1} $cm.^{-1}$.

calculations, which attempted to discuss the problem as a unidimensional one.

Dr. D. R. Inglis directed attention to Prof. Urey's view that the lighter constituents of the earth might have condensed first. Thus heavier materials trapped in the outer parts of the earth might drop down through the core from time to time. This might provide an explanation of the variations of the length of the day and would also provide an alternative explanation of the cause of core motions.

S. K. RUNCORN

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OBITUARIES

Prof. R. J. D. Graham

PROF. ROBERT JAMES DOUGLAS GRAHAM died at his home in St. Andrews on September 3. He was born at Perth on July 20, 1884, the son of Dr. John Thomas Graham, medical officer for Perthshire. After an early education at Perth Academy, Graham entered the University of St. Andrews in 1901. Somewhat uncertain as to the course of study to pursue, he began with an M.A. degree in 1904. At first he was inclined to follow a career in the Church, but he made early and stimulating contacts with Prof. Patrick Geddes, with Sir D'Arcy Thompson, and later with that very enthusiastic teacher, Prof. R. A. Robertson, the first holder of the chair of botany at St. Andrews. The influence of these men swayed Graham entirely to the side of science, and it was Robertson who made him a botanist. By 1906 he had completed with distinction his science degree in botany, zoology and geology. Thereafter he continued for a brief period as a Carnegie Scholar at St. Andrews and spent some months in Germany familiarizing himself with the language.

Early in 1907 Graham was appointed an economic botanist in the Indian Agricultural Service. After a short stay at Pusa, where for a time he deputized for the Imperial Economic Botanist, he was directed to the more permanent post of economic botanist to the Government of the Central Provinces. He was the first to occupy this post, which he held from 1908 until 1917. Graham thus had a wide field in which to operate, including the establishment of college curricula and the organization of a considerable amount of research work on the applied aspects of his subject. To that end he was enabled to visit many agricultural institutions throughout India and to equip the Central Provinces with a very adequate scheme of development. He was much interested in the improvement by selection and hybridization of wheat, rice, millet, linseed, potatoes, oranges, etc. A decided measure of success attended this work, particularly in the production of rust-resisting wheats and improved strains of rice and millet; so much so that for some years after he had left the Provinces it could be said that many thousands of acres were sown annually with strains of cereals evolved by him. One of the many results of his work was the composition of a thesis—"The Economic and Systematic Botany of the Central Provinces of India"—which was accepted by his old University as qualifying him for the degree of D.Sc. in 1917.

It was evident from the first that Graham possessed a flair for administration, and this was fully exemplified in the years to come. In the First World War he immediately volunteered for active service, but it was not until November 1917 that permission was granted. Then he joined the Indian Army Reserve of Officers as a second lieutenant and forthwith was directed to Mesopotamia. In view of his previous experience in the science and practice of agriculture, he was within a few months appointed assistant director of agriculture with the rank of lieutenant-colonel. In this capacity he continued until March 1919, when his qualities induced the authorities to appoint him director of agriculture and also director of military farms. He occupied this responsible position until he was released from military service in 1920. His department was regarded officially as one of the most efficient and popular in Mesopotamia, and he was duly mentioned in dispatches.

Upon his retiring from service in the East in 1921, he was invited by Sir Isaac Bayley Balfour to join the University of Edinburgh as a senior lecturer in botany. For nearly thirteen years he took a full share in the teaching of large classes, particularly in courses of plant physiology, plant breeding and genetics.

In 1934 he was appointed to succeed his old teacher, Prof. Robertson, in the chair of botany at St. Andrews, where his ability for administration again received early recognition. Year after year he was re-elected dean of the Faculty of Science, and for six years was chosen by the Senatus as an assessor to the University Court. In these fields he was a conspicuous success—without detriment to the work of his chair. In addition to his own Department he had the general supervision of the Department of Botany at Dundee. His influence was well seen in the completion of the botanical laboratories, in the development of a very fine University Botanic Garden with an extension by the Firth of Tay devoted to the cultivation of sea-shore plants, and in the re-establishment of the Gatty Marine Laboratory. His own studies, as well as his attraction to plant physiology and applied botany, led him to devote much of his attention to vegetative propagation. In this he had the close co-operation of the late Mr. L. B. Stewart, and from this association there resulted numerous publications.

Graham was elected a fellow of the Royal Society of Edinburgh in 1924, he was a member of Council during 1938–39, and a vice-president for the period 1944–47. For some years he was honorary secretary of the Botanical Society of Edinburgh and president in 1942–43. Almost yearly expeditions into the hills gave him a very complete acquaintance with the Scottish alpine flora. On these excursions he was in his element, for he was as vigorous in body as in mind. At St. Andrews he took a great interest in all the social and athletic activities of the student body. As he had joined the University Rugby Club in 1901 and was captain in 1906, he could enter into the direction of sports with zest, and until a few years ago could take a share in the field of play.

Only recently did his stalwart frame show any indication that all was not well, and he was warned that he must exercise great care. But he continued to work until the day before his death, and then passed away very peacefully in his sleep. His many friends abroad and at home share in the deep loss sustained by St. Andrews—a loss to which expression has been given from many quarters. He is survived by his wife, one son and three daughters.

W. Wright Smith

Prof. R. Goldschmidt

The death occurred on October 30 of Prof. Rudolf Goldschmidt, a pioneer of electrical engineering, at the age of seventy-four.

Goldschmidt was born in Mecklenburg on March 19, 1876. Although the first years of his life were spent in modest surroundings, and his parents had intended him for a merchant career, his scientific talents and independence of mind soon asserted themselves. He studied engineering at the technical colleges at Berlin and Darmstadt, where he became lecturer at the age of twenty-one. In 1900 he entered industry, and came to England in 1902, joining Messrs. Crompton-Parkinson, Ltd., Chelmsford; later he went to the Metropolitan-Vickers Electrical Co., Ltd. (then the Westinghouse Co.), in Manchester.

By this time his original technical thinking and inventive genius were already recognized in wider circles, and he had a number of books, papers and patents to his credit, chiefly concerned with alternating current machinery. In 1905 he received an award from the Institution of Electrical Engineers.

Goldschmidt returned to Darmstadt in 1907 as reader, later professor of electrical engineering. He occupied this chair, however, for a few years only, as his most important invention now preoccupied him. This was the high-frequency alternator, a machine which at the time revolutionized wireless telegraphy and entered text-books as the Goldschmidt alternator. It permitted, for the first time, telegraphing without cable from Germany to the United States. He built the large wireless station at Eilvese, near Hanover, and a similar American one at Tuckerton, being director of the former and of the 'Homag' (High Frequency Company) throughout the First World War. A historical exchange of greeting telegrams between President Wilson and the Kaiser (who ceremonially opened his station a fortnight before the War) is still among his souvenirs. This and later work brought him some of the highest public honours in Germany.

After the War many other inventions occupied his mind, in particular an electric hammer which is widely used to-day, the British development being the 'Kango' hammer. His versatility enabled him to contribute to the most diverse scientific fields, the patents ranging from internal combustion engines to telephones and a pulse-recording machine. Among his friends he counted Prof. A. Einstein, with whom he co-operated on one invention.

He lived in Berlin during 1911–34, when he emigrated to England with his family as a refugee from the Nazis, being of Jewish faith. He became a naturalized British subject in 1939. In Britain his inventive activity continued. Among other things he developed a new type of deaf-aid, and in order to test this, he subjected himself to six operations, the last one impairing his hearing.

During the Second World War he pursued, with the support of the Air Ministry, some inventions of special character, putting all his energy into the war effort in his own manner. He lived in London, but in 1940 joined his son in Sheffield. Here he became consultant, later member of the staff, of the B.S.A. Group Research Centre, working chiefly for the B.S.A. Co., Ltd., Birmingham, on several projects, and moved to Birmingham in 1949. During these last years, though more than seventy years of age, he still devoted his whole life to his work with youthful energy, to the admiration of his colleagues and many friends, until his fatal illness in August last.

Dr. Goldschmidt married in 1905. His wife died in 1933; he leaves one daughter and three sons. Despite his technical preoccupation, he was a man of outstanding charm and personality. His sense of humour, generosity and kindliness, his love of Nature and of children were his chief qualities. He was a patient teacher who loved nothing better than to pass on his deep knowledge to his students and associates.

Prof. S. J. Truscott

There is not a mining field throughout the world where the death on September 26 of Samuel John Truscott will not have been noted with sorrow. By personal contact at the Royal School of Mines, at meetings of the Institution of Mining and Metallurgy and by visits overseas, he was known personally to many, and those who did not have the pleasure of meeting him have derived great benefit from his writings. He was a great teacher, a strict adherent to what is best in his profession and a prolific and stimulating writer.

He was born in 1870, received his scientific training at the Royal School of Mines, and then obtained a wide professional experience over twenty-seven years in overseas mining fields, particularly in the East Indies and in South Africa. He was of Cornish descent and had all the traditional Cornish love of adventure. As a young man he gloried in the life of the mining fields, such as Malaya, 1889–92, and the Witwatersrand, 1894–97.

In 1913 Truscott returned to the Royal School of Mines and in 1919 was elected to the chair of mining, which he held until 1935. His lectures were remarkable for their clarity, illustrated by an astonishing knowledge of modern developments derived from his personal experiences and close study of the technical journals in the English, French and German languages.

Truscott was president of the Institution of Mining and Metallurgy (1920–21), was awarded its Gold Medal in 1937 and made an honorary member in 1948. The University of the Witwatersrand conferred on him an honorary doctorate in the Faculty of Engineering in 1930 and he was elected an honorary fellow of the Imperial College in 1945.

He published a number of treatises on mining subjects, two of which, namely, "Ore Dressing" and "Mining Economics", are the standard works in their respective subjects in the English language.

In manner he appeared to be somewhat austere; but there was an imp of mischief which peeped out unexpectedly to the complete astonishment of his students and his younger friends. His older friends knew him as a generous warm-hearted friend who was always ready to put his great knowledge at their disposal.

J. A. S. Rrrson

NEWS and VIEWS

Prof. E. D. Adrian, O.M., F.R.S.: President of the Royal Society

THE election of Prof. E. D. Adrian to the presidency of the Royal Society will bring great pleasure throughout the world of science, both in this further homage to the distinction of his work and also in that the Royal Society will have those personal qualities which have made his recent ambassadorial work for Unesco and as Foreign Secretary to the Royal Society so conspicuously successful. Prof. Adrian's work has had a profound effect on the course of biological science in the last two decades. His early training with Keith Lucas and in clinical neurology up to 1918 equipped him to make full use of the opportunities to re-investigate much of nervous function presented by the advent of the valve amplifier, which enables the messages passing in nerve trunks to be tapped and recorded with instruments rapid enough to follow them but too insensitive to be used without amplification. In 1926 his discovery with Zotterman of the rhythmic discharge of impulses by a single sense organ in muscle was rapidly followed by many observations showing this to be a general principle of signalling used throughout the nervous system, in motor as well as sensory nerves. With many pupils and collaborators in the following years, many of the outstanding uncertainties of sensory function were made plain. He then turned his attention to the electrical changes of the brain and, following Berger's early work on these, laid the foundation of electroencephalography, which has since become an important new branch of neurology. In recent years his work has been on olfaction and has given us objective facts on which further understanding of this most baffling of the sense organs can be built.

Prof. Adrian's work has been characterized by simplicity in conception, going straight to the fundamental point where the new techniques could supply the missing links in the older knowledge. This has led him far afield in comparative neurology, from the optic ganglion of the water beetle to the auditory nerve of the alligator: the cortex of the pony, ape, or himself have all provided material for his experiments. His work has mapped out many new fields of experiment which have become active fields of research all over the world. In spite of the extreme difficulty of many of the techniques he has used, his experiments are all done by his own hands, which have a skill in operation that is deceptive in the speed with which a preparation is made. His work, presented either in papers or lectures, has a clarity and simplicity that reveal a mind under the sternest logical discipline and with complete freedom from obliquity in thought; and whether he speaks to a learned society or to a class of medical students, his audience are made to understand matters they thought too difficult for them.

Electrical Engineering at University College, London: Prof. F. Brailsford

DR. F. BRAILSFORD has been appointed as from January 1, 1951, to the second chair of electrical engineering, tenable at University College, London, with special responsibility for heavy-current work. He has a very wide experience in industrial research, having been a member of the staff of the Research Department, Metropolitan-Vickers, Ltd., Manchester, since 1929. In recent years he has given close attention to magnetic materials, and he is particularly well known both in Great Britain and in the United States for his important contributions in that field of study. Dr. Brailsford's little book on "Magnetic Materials", published in 1948 as one of "Methuen's Monographs", is an authoritative work. In the academic sphere Dr. Brailsford has had experience as a part-time teacher both at the University of Manchester and at the Manchester College of Technology. He took a London B.Sc.(Eng.) external degree with first-class honours in 1927 and Ph.D.(Eng.) in 1939. As a full member of the Institution of Electrical Engineers, he has been awarded the Kelvin Premium and the Mather Premium of that Institution for scientific papers presented to it.

British Railways Research Organization

THE Railway Executive has decided to integrate the research facilities of the different regions of British Railways into a single Research Department. This is in accordance with the recommendation of a committee set up by the British Transport Commission under the chairmanship of Sir William Stanier. The Department will be under the control of a Director of Research responsible directly to Sir Eustace Missenden, chairman of the Railway Executive. It will have seven divisions, each under the immediate control of a superintendent. The divisions will be: (1) Chemistry, embracing existing laboratories in each region; these laboratories will continue to be concerned with work arising in the regions, but major researches of a chemical nature will be allocated to whichever laboratory is most suitable (laboratories are situated at Ashford, Crewe, Darlington, Derby, Doncaster, Glasgow, Horwich, Stonebridge Park, Stratford, Swindon and Wimbledon; headquarters in London); (2) Engineering; (3) Metallurgy; (4) Protective Coatings; (5) Physics; (6) Textiles; (7) Operational Research (headquarters in London). Divisions 2–6 will be at Derby, where the necessary laboratory facilities and staff already exist; there will also be a subsidiary engineering laboratory at Ashford. The Research Department will establish a central library and information centre.

The appointments have already been announced of Mr. T. M. Herbert, formerly research manager, L.M.S., to be director of research, and of Mr. E. Morgan to be assistant director. The following appointments as superintendents of the various divisions of the new Department have been made: Mr. T. Baldwin (senior assistant (engineering), Scientific Research Department, Derby), Engineering Division (Derby); Mr. T. H. Turner (chief chemist and metallurgist, Mechanical and Electrical Engineering Department, Doncaster), Metallurgy Division (Derby); Mr. T. A. Eames (senior physicist, Scientific Research Department, Derby), Physics Division (Derby); Mr. F. Fancutt (paint technologist, Scientific Research Department, Derby), Chemistry Division (Euston); Mr. C. G. Winson (textile technologist, Scientific Research Department, Derby), Textile Division (Derby); Mr. M. G. Bennett (manager, General Research Department, Euston), Operational Research Division (Euston).

International Film Coupon Scheme

A SCHEME has been organized by the United Nations Educational, Scientific and Cultural Organization which will enable soft currency countries to purchase educational, scientific and cultural films from hard-currency areas, and will facilitate purchase

and sales between one soft-currency country and another. So far, twenty-four countries have joined in the project. Coupons will be marketed in Great Britain by the British Film Institute, 164 Shaftesbury Avenue, London, W.C.2, which will also be the central body dealing with imports and exports under the scheme. Intending purchasers must satisfy themselves that the particular film they want is educational, scientific or cultural, and also make sure of the availability and price of the film. The British Film Institute will provide the necessary import form and in due course obtain the film, clear it through Customs and hand it over to the purchaser. Where the Institute receives a request from abroad, supported by the appropriate coupons, for the purchase of British films, it will get into contact with the owner and make arrangements for shipment; payment for films purchased in this way will be made by the Institute. No orders for non-British films will be accepted from a foreign purchaser, and films must be supplied to foreign purchasers by outright sale without any contingent payments.

British Jute Trade Research Association: Annual Meeting

At the annual general meeting of the British Jute Trade Research Association, held on November 14 in the offices of the Association, Kinnoull Road, Kingsway West, Dundee, the chairman of the Council, Mr. George E. Scott, in moving the adoption of the accounts and annual report for the year ending June 30, said that a considerable expansion in staff and plant has taken place during the past year. Commenting on the great increase in basic knowledge relative to jute, Mr. Scott said that all sections of the industry are utilizing the facilities made available by the technical inquiry service of the Association, particularly with regard to day-to-day problems; the steady increase in the number of such inquiries illustrates the reliance on the work of the Association. Mr. Scott also referred to the publicity value of the research station to the industry, impressing as it did upon users of jute goods the desire of the industry to do all within its power in the provision of quality products and materials for special purposes. The director of research, Mr. H. Corteen, reviewed the different ways in which the Research Association can be of assistance to its members. In order to hasten the practical application of the results of research conducted in the Association's laboratories and workshops, a series of training schemes are being set up, whereby personnel of member firms can be trained in particular aspects of work. During the day of the meeting, approximately 170 of the supervisory personnel of member firms visited the Association's premises and were shown the various research investigations being carried on, this being the first 'open day' organized by the Association for that purpose.

X Disease of the Peach

A virus attacking peach and chokecherry (*Prunus virginiana*), and rather appropriately known as X disease, is now of considerable importance in the north-eastern United States. Ernest M. Stoddard (Conn. Agric. Exp. Sta. Bull. 506; pp. 19; New Haven, U.S.A.; May 1947) has investigated methods of spread and possible control of the trouble. The virus is transmitted by budding or grafting, but not by mechanical means; it can spread on chokecherries and from them to peach, but not from peach to peach and, in all probability, not from peach to chokecherry. An obvious method of control is to eliminate chokecherries from the neighbourhood of peach orchards. It is, however, claimed that the virus is inactivated in diseased living peach buds by soaking such buds in aqueous solutions of chemicals which include various sulphonamides, quinolines, and even calcium chloride. Living peach trees can also be immunized against artificial inoculations of X disease by watering the soil with various aqueous solutions. Heat treatment of peach buds is also claimed to lower the infectiveness of the virus. It would appear that important issues are raised by this work—so important that, without any disrespect to the author, they merit independent confirmation.

Ceylon Coconut Quarterly

The coconut industry is a major industry in Ceylon and almost entirely in the hands of the Ceylonese. Coconut products are the second best exchange earner for the island. In December 1928 an Ordinance to provide for the establishment of a Coconut Research Scheme became law, though its finances were always inadequate. The Ordinance required that the board of the Research Scheme should, by the provision of information, give practical assistance to persons engaged in the industry. Hitherto, it had only been possible to issue advisory leaflets at irregular intervals with an occasional article in the *Tropical Agriculturist*. But the absence of a regular journal was always felt as a serious omission. The *Ceylon Coconut Quarterly* has now come into being (**1**, No. 1, January–March 1950; Lunuwila: Coconut Research Scheme). Messages of welcome are published from the Prime Minister of Ceylon and the Ministers of Agriculture and Lands, the Food and Co-operative Undertakings, and Commerce and Trade. As the Prime Minister points out, neglect in the plantations existed before the Second World War, and during the War cultivation, manuring and replanting were not done. The establishment of nurseries and the dissemination of young seedling plants by the Research Centre has done much to improve crops. It is said that the yields from crops grown from the specially selected nuts and seedlings may yield 5,000 nuts per acre, instead of the average 1,800 from more or less uncultivated plantations. The aim of the *Quarterly* is to provide information of all kinds on the subject of the industry and to make the information available not only to the larger growers, but also to the smallholders, who form the majority of the coconut producers.

Colonial Service: Recent Appointments

The following appointments in the Colonial Service have recently been announced: W. T. Dalgarno (senior agricultural officer, Nigeria), principal farm industries officer, Department of Commerce and Industries, Nigeria; M. W. Gibbon (senior agricultural officer, Nigeria), principal agricultural officer, Nigeria; A. E. Moss (senior agricultural officer, Gold Coast), assistant director of agriculture (cocoa industry), Gold Coast; R. J. M. Swynnerton (senior agricultural officer, Tanganyika), assistant director of agriculture (field services), Kenya; D. A. Russell (principal, Government Technical School, Takoradi, Gold Coast), chief inspector of education (technical), Nigeria; J. F. Bates, entomologist, British Guiana; F. A. Carver, agricultural officer, Fiji; C. R. Dickson, agricultural officer, Gold Coast; L. Johnson, economic botanist, Trinidad; A. S. MacDonald, agricultural

officer, Sierra Leone; J. R. Milburn, agricultural officer, Federation of Malaya; R. E. Rowe and A. I. Taylor, agricultural officers, Nigeria; E. N. G. Cooling, conservator of forests, Northern Rhodesia; K. M. Lamb, assistant conservator of forests, Nigeria; R. M. Lawton, assistant conservator of forests, Gold Coast; D. S. Lowson, R. H. M. Nisbet and J. D. Whitaker, assistant conservators of forests, Federation of Malaya; P. Hardwick and F. Whyte, geologists, British Guiana; L. Piper, geologist, Nigeria; W. N. Woodhead, geologist, Sierra Leone; S. J. Curry, scientific officer (entomologist), Anti-Locust Research, Cyprus; Dr. M. T. Gillies, medical research officer, grade 3 (medical entomologist), East Africa Malaria Unit, East Africa High Commission; J. F. Griffiths, scientific officer (micro-climatologist), Desert Locust Survey; T. M. Docker, veterinary officer, Tanganyika; R. C. Armstrong, sociological research officer, Nigeria; W. P. Bewy, livestock officer, Veterinary Department, Tanganyika; H. S. Gair, geologist, Northern Rhodesia; D. L. Jennings, research officer (genetics), East African Agriculture and Forestry Research Organization; E. H. O. Martin, fisheries officer, Tanganyika; C. W. Montgomery, soil survey officer, Gold Coast; Miss J. E. Mulholland, statistician, Medical and Survey Department, East Africa High Commission; H. N. Sanson, meteorologist, East Africa High Commission; J. S. Scott, fisheries officer, Fisheries Department, Federation of Malaya; A. M. S. Smith, assistant conservator of forests, Uganda; J. J. Soulsby, fisheries officer, Northern Rhodesia; C. G. N. Warren, agricultural survey officer, Gold Coast.

Crosby Hall Scientific Exhibition

Under the auspices of the Crosby Hall Endowment Fund, a Scientific Exhibition will be held at the Imperial College of Science and Technology during December 26–30. Together with practical scientific demonstrations, films will be shown and a series of lectures will be given. Among those who will be lecturing are: Dr. G. M. Bennett, Miss Enid Blyton, Mr. L. J. F. Brimble, Prof. Winifred Cullis, Miss Mary Field, Sir Alexander Fleming, Prof. H. Hartridge, Dr. H. S. Holden, Dr. A. Hunter, Prof. R. P. Linstead, Mr. Robert Silvey, Dr. Keith Simpson, Dr. Marie Stopes, Dr. W. E. Swinton, Dr. Mary Waller, Sir Robert Watson-Watt and Dr. W. D. Wright. Further information can be obtained from Miss R. Part, Crosby Hall Endowment Fund, Crosby Hall, Cheyne Walk, London, S.W.3.

University of London: Appointments

It is announced from the University of London that Dr. C. H. Dowker has been appointed to the University readership in mathematics tenable at Birkbeck College. The title of reader in the University has been conferred on the following in respect of the subjects mentioned: Mr. D. N. de Garrs Allen (applied mathematics, Imperial College of Science and Technology); Dr. R. J. Harrison (anatomy, Charing Cross Hospital Medical School); Mr. E. J. Pryor (mineral dressing, Imperial College of Science and Technology).

Announcements

Mr. T. A. Brinkly, an experimental officer at the Atomic Energy Research Establishment, Harwell, has been appointed research assistant to Prof. E. W. Titterton, of the Australian National University, Canberra.

Dr. E. M. Crowther and Mr. F. C. Bawden have been appointed deputy directors responsible for the Soil Division and Plant Pathology Division respectively of Rothamsted Experimental Station.

Dr. A. R. Lee has been appointed a deputy director at the Road Research Laboratory, Department of Scientific and Industrial Research. His duties will concern research on materials and methods of construction of roads. He will have the rank of a deputy chief scientific officer. By this appointment the two sides of the work at the Road Research Laboratory will each have a deputy director responsible to the director of road research (Dr. W. H. Glanville); Dr. R. J. Smeed, the other deputy director, is concerned with the work of the Safety and Traffic Division. Dr. Lee will be best known to road engineers for his work on bituminous road materials and surfacings.

Mr. George L. V. Hooton has been appointed a lecturer on the staff of the Department of Education of the International Wool Secretariat. Mr. Hooton, who is a graduate of the University of Leeds, and comes of a Yorkshire sheep-farming family, will lecture on all aspects of wool, both in the schools and in the field of further education, in the West Riding of Yorkshire and in the north of England generally.

The fourth Louis Bleriot Lecture of the Royal Aeronautical Society will be given in London on February 23, 1951, by M. Maurice Roy, who will speak on "Power Versus Weight in Aviation". The thirty-ninth Wilbur Wright Memorial Lecture of the Society will be given in September 1951 by Mr. A. E. Raymond, vice-president (engineering) of the Douglas Aircraft Co., Inc., of California; the exact date and title of the Lecture will be announced later. Further details may be obtained from J. Laurence Pritchard, secretary of the Royal Aeronautical Society, 4 Hamilton Place, London, W.1.

The British Plastics Federation, as administrators of the Bowen (Cables and Plastics) Prize Fund, is offering, for award in June 1951, up to three prizes of maximum value £150 for papers on chemistry, physics, engineering or chemical engineering, having a bearing on plastics or polymers, read during September 1950–June 1951 before the Plastics Institute or its branches, or the Plastics and Polymer Group of the Society of Chemical Industry, including the symposium or the convention held in connexion with the British Plastics Exhibition in June 1951; alternatively a paper may be submitted direct. Contributions must reach the general manager of the British Plastics Federation, 47–48 Piccadilly, London, W.1, not later than June 29, 1951.

Under the provisions of the Fulbright Programme, travel grants are available to citizens of the United Kingdom and Colonies to go to the United States for academic or educational purposes, provided that they have the financial support in dollars for the visit and are affiliated to an American institution of higher learning. The Fulbright grants cover the cost of travel from the candidate's home to America and return, and are available during June 1, 1951–May 31, 1952. Further details can be obtained from the United States Educational Commission in the United Kingdom, 55 Upper Brook Street, London, W.1; applications must be submitted by March 31 (those travelling between June 1 and July 31) or July 1 (those travelling after August 1).

RADIOCHEMICAL EQUILIBRIA IN IRRADIATED WATER

By Dr. P. BONET-MAURY and M. LEFORT
Laboratoire Curie, Institut de Radium, Paris

THE formation of hydrogen peroxide in water to which sulphuric acid and titanium sulphate have previously been added, by exposure to X- and alpha-radiation, has already been studied[1]. The hydrogen peroxide combines, as rapidly as it is produced, to form a stable coloured titanic complex. It would be expected that under these conditions subsequent radiodecomposition of hydrogen peroxide would be prevented, so that the whole of it produced by the various reactions which lead to its formation during irradiation may be measured by the photocolorimetric method already described[2].

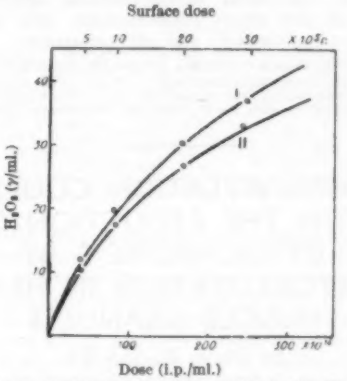
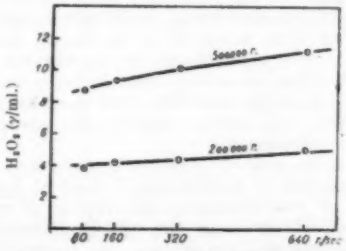


Fig. 1. I, Reagent before (intensity : 650 r./sec.) ; II, reagent after (intensity : 650 r./sec.)

If water, brought to the same *p*H (1·2) by addition of sulphuric acid, is irradiated under the same conditions but in the absence of titanium sulphate, and the latter is added after the end of irradiation, then the measured production of hydrogen peroxide is not the total amount produced but an amount corresponding to equilibrium between the rate of formation and the rate of destruction characteristic of the particular radiation intensity used. (The intensity of the absorbed radiation is defined as that amount of energy transferred to unit volume of water in unit time ; it may be expressed in ergs/ml./min., in eV./ml./min., or in ion pairs/ml./min.) If one compares the yield of hydrogen peroxide when the reagent is added before, with that when it is added after, the irradiation, one can evaluate the importance of the decomposition reactions. By varying the amount of sulphuric acid, the whole range of *p*H from 1·2 to 7, corresponding to pure water, may be investigated ; by substituting hydrochloric acid for sulphuric acid, we ensured that the effect observed depends upon the *p*H and not upon the anion. The alkaline *p*H range may also be investigated by the addition of suitable reagents.



Intensities (100 r./sec. = 8·4 × 10¹³ i.p./ml./sec.)

Fig. 2. Effect of intensity (*p*H 1·2)

(*a*) *p*H 1·2. At the maximum intensity feasible with our equipment (650 r./sec.), X-rays give hydrogen peroxide in amounts smaller than those obtained when the reagent is added before the irradiation (Fig. 1). For a given dose the relation of formation of hydrogen peroxide to intensity is shown in Fig. 2. Increasing the duration of exposure was without effect in our previous studies[1]. In the case of alpha-radiation, neither the time at which the reagent is added nor the duration of exposure has any effect on the yield of hydrogen peroxide so long as the initial intensity is higher than 0·5 mC./ml. or 0·8 × 10^{13} ion pairs/ml./sec. (table, p. 982). At lower intensities, a slightly smaller yield is recorded, which may reasonably be ascribed to the fact that the duration of exposure was much greater (48 hr.), so that the variation in the radiation intensity due to decay of the radon was no longer negligible.

(*b*) *Variable pH.* In the case of X-radiation, the amount of hydrogen peroxide produced depends on the *p*H when irradiations are carried out at a constant dose and constant intensity (Fig. 3). At *p*H 7, the concentration of hydrogen peroxide is about one-half that produced at *p*H 1·2, whereas at *p*H 12 it is only one-third that at *p*H 1·2.

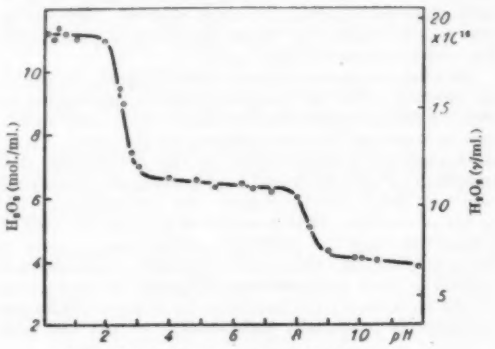


Fig. 3. Effect of *p*H (intensity : 640 r./sec.)

Changes in *p*H do not alter the formation of hydrogen peroxide by alpha-rays when the radon concentration is higher than 0·5 mC./ml., but an appreciable diminution is observed with lower concentrations.

(*c*) *p*H 7. *Pure water saturated with oxygen.* Hydrogen peroxide formation by X-rays depends on the intensity at which the dose is delivered, and the relation of the final concentration observed to this intensity is shown in Fig. 4. It is remarkable that the hydrogen peroxide production by alpha-rays is independent of the radiation intensity when the initial radon concentration is higher than 1 mC./ml. The smaller yield of hydrogen peroxide observed at lower concentrations seems to be due to secondary decom-

RADIOCHEMICAL YIELD ($t = 18°$)

	Water	With titanic reagent	With sulphuric acid	Pure non-degassed		Pure oxygen-freed
	*p*H	1·2	1·2	7·0		7·0
X-rays	Intensity { r./sec.	640	640	640	160	640
	i.p./ml./sec.	$5·4 \times 10^{14}$	$5·4 \times 10^{14}$	$5·4 \times 10^{14}$	$1·34 \times 10^{14}$	$5·4 \times 10^{14}$
	Initial yield G_i	2·7	1·95	1·05	0·60	0
	Initial yield M/N	0·9	0·65	0·35	0·20	0
	Yield for 10^{13} i.p./ml. G_{13}	1·25	1·0	0·63	0·27	0
	Yield for 10^{13} i.p./ml. M/N	0·42	0·35	0·21	0·09	0
α-rays	Intensity (i.p./ml./sec.)	8×10^{12}	8×10^{12}	8×10^{12}		8×10^{12}
	G	0·9	0·86	0·86		0·86
	M/N	0·28	0·275	0·275		0·275

position reactions occurring during the long duration experiments.

Radiochemical yield. The radiochemical yield, G, is practically constant for alpha-rays (initial intensity higher than 8×10^{12} i.p./ml./sec.): $G = 0·9$, that is, 0·29 mol. of hydrogen peroxide per alpha ion-pair. It is assumed that the average energy expended in producing an ion-pair by alpha-radiation is 35 eV.

For X-rays, on the contrary, this yield largely depends on the experimental conditions. It increases with temperature, intensity and concentration of dissolved oxygen, but decreases with dose and *p*H. In the accompanying table both the initial yield (dose ~ 0) and the yield resulting from a given dose (10^{13} i.p./ml.) have been recorded. The former is believed to correspond to the rate of production of hydrogen peroxide and to be unaffected by decomposition reactions; the latter represents the equilibrium between formation and decomposition under the conditions of the experiment. These results demonstrate that the X-ray yield in pure *p*H 7 aerated water may sometimes be higher and sometimes lower than the alpha-ray yield, according to the intensity and the dose used in the irradiation. Densely ionizing particles alone give a radiochemical yield higher than that of electrons in oxygen-free water, in which the yield is practically zero for electrons in this case.

These experiments support the interpretation which we proposed for our previous results, according to which hydrogen peroxide formation by X- and alpha-rays is controlled by two separate mechanisms. These mechanisms are conditioned by the geometrical distribution of the hydroxyl and hydrogen ion groups resulting from the ionization and excitation of the water molecules. If it is assumed that in the case of alpha-rays only the hydroxyl groups play a part in the phenomenon, then the very high local concentration of these radicals along the track of the particle would account for the fact that the yield of hydrogen peroxide is practically independent of *p*H and also of intensity, despite the fact that the intensity determines the mean concentration of hydroxyl radicals throughout the bulk of the solution. In the case of X-rays, on the other hand, the hydroxyl and hydrogen ion local concentrations approximate closely to the mean concentration and may be influenced by intensity and *p*H variations.

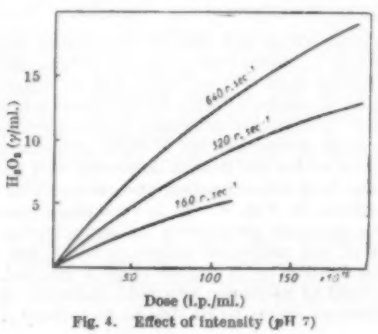


Fig. 4. Effect of intensity (*p*H 7)

[1] Bonet-Maury, P., and Lefort, M., *Nature*, **162**, 381 (1948).

[2] A recent review of this subject will be found in the reports of the symposium held in 1948 at the Notre-Dame University (Indiana, U.S.A.), published in the *J. Phys. and Coll. Chem.*, 52 (1948).

PHOSPHORYLATION COUPLED WITH THE REDUCTION OF CYTOCHROME C BY α-KETOGLUTARATE IN HEART MUSCLE GRANULES

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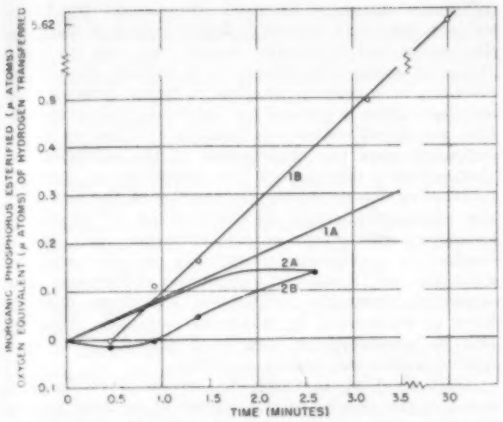
THERE is general agreement that during the oxidation of most intermediary metabolites (succinate appears to be exceptional), about three atoms of phosphorus may be esterified per atom of oxygen consumed[1–4]. Belitzer and Tsibakowa[5] and Ochoa[6] pointed out that a ratio greater than one implies that the phosphorylation reaction must occur at more than one point in the respiratory chain over which the hydrogen atoms of the substrate pass on their way to oxygen. Later, Lehninger[3] was able to show that, with β-hydroxybutyrate as substrate, all the phosphorylation occurred between reduced cozymase and oxygen and none between substrate and cozymase. With substrates such as pyruvate or α-ketoglutarate the primary dehydrogenation, that is, that between substrate and the first acceptor, might also contribute to phosphorylation[7].

The location of the phosphorylation has now been narrowed by experiments in which cytochrome *c* was used as the final acceptor of hydrogens from the substrate. The reoxidation of cytochrome *c* was prevented, either by adding cyanide or by excluding oxygen. α-Ketoglutarate has been used exclusively as substrate, but further experiments are planned with other substrates.

Since the amount of hydrogen transfer was limited by the amount of cytochrome *c* used as hydrogen acceptor, it was necessary to employ a sensitive method of determining the phosphorylation. By adding glucose and hexokinase, the inorganic phosphate which disappeared was finally obtained as glucose-6-phosphate. This was measured on the



Esterification of inorganic phosphate during oxidation of α-ketoglutarate by oxygen (curves 1*A* and 1*B*) or cytochrome *c* (curves 2*A* and 2*B*). NaF, 0·04 *M*; phosphate buffer, *p*H 7·3, 0·0348 *M*; glucose, 0·0167 *M*; cytochrome *c*, 10^{-4} *M*; adenylic acid, 0·001 *M*; adenosinediphosphate, 0·001 *M*; α-ketoglutarate, 0·0067 *M*; hexokinase; Mg, 0·005 *M*; 0·1 ml. heart muscle preparation (1·6 mgm. fat-free dry weight) in all flasks. Curves 2*A* and 2*B* contained, in addition, 0·01 *M* potassium cyanide. Curves *A*, hydrogen transfer; Curves *B*, hexose phosphate formed. Temperature 23·3–24·4° in different experiments; times adjusted to correspond to 24·4°, assuming $Q_{10} = 2$

supernatant from a trichloracetic acid precipitation by a sensitive enzymic method (based on Racker's[8] method of determining hexokinase activity).

Under the experimental conditions, adenosinediphosphate was much more efficient than adenylic acid as primary phosphate acceptor. Adenylic acid was also added, however, in order to inhibit myokinase, which caused an appreciable transfer of the terminal phosphorus of adenosinediphosphate to glucose in the absence of any oxidation. Fluoride (0·04 *M*) was added to inhibit adenosinetriphosphatase.

The enzyme preparation used consisted of washed granules obtained by differential centrifugation of an extract prepared by grinding washed cat heart mince with sand and phosphate buffer, *p*H 7·3.

The accompanying graph shows the results in which both oxygen and cytochrome *c* were used as the final hydrogen acceptor. In the latter case, 0·01 *M* potassium cyanide was added to prevent the oxidation of reduced cytochrome *c*. The rate of hydrogen transfer was followed manometrically in the first case and spectrophotometrically (increase of absorption at 520 mμ) in the second. The values shown have been corrected for a zero time blank and for a very small esterification obtained in presence of cyanide, but in the absence of cytochrome *c* (due to slight myokinase activity).

It is apparent that whether oxygen or cytochrome *c* was the final hydrogen acceptor, there was an initial lag of phosphorylation behind hydrogen transfer. In fact, when cytochrome *c* acted as the acceptor, most of the glucose phosphate was formed after the cytochrome *c* was completely reduced. This lag must be due to the accumulation, in the very early stages of the reaction, of an intermediate in the overall phosphorylation reaction. The intermediate could be either adenosinetriphosphate or a compound formed prior to it, or both.

When oxygen is the final hydrogen acceptor, the effect of the lag on the measured phosphorus–oxygen ratio can be made negligible by running the experiment for a sufficient period. It is apparent from the value obtained at 30 min. in the graph that the phosphorylation system is stable for at least this period under the conditions used. The effect of the lag on the phosphorylation coupled with the reduction of cytochrome *c* can be minimized by allowing the reaction to proceed for some time after all the cytochrome *c* is reduced.

The accompanying table summarizes an experiment in which the phosphorus–oxygen ratio obtained with cytochrome *c* is compared with that obtained with oxygen as final hydrogen acceptor. The reoxidation of the cytochrome *c* was prevented in three ways: (1) by using oxygen-free nitrogen as the gas phase; (2) with 0·001 *M* potassium cyanide; (3) with 0·01 *M* potassium cyanide.

The cytochrome *c* was completely reduced in 5·6 min. When 0·001 *M* potassium cyanide was

Esterification of Inorganic Phosphate during Oxidation of α-Ketoglutarate by Oxygen or Cytochrome *c*[1]

Volume, 3·1 ml. Fluoride, 120 μ moles; phosphate buffer, *p*H 7·3, 109 μ atoms P; glucose, 50 μ moles; adenylic acid, 3 μ moles; adenosinediphosphate, 3 μ moles; Mg, 15 μ atoms; hexokinase; 0·2 ml. heart muscle preparation (3·3 mgm. fat-free dry weight) in all flasks. Other additions as shown.

No.	α-Keto-glutarate (μ moles)	Cyt. *c* (μ moles)	Conc. of potassium cyanide (*M*)	gas phase	Time[1] (min.)	Hydrogen acceptor	Oxygen equivalent of hydrogen transferred (μ atoms)	Glucose phosphate[2] found (μ moles)	Δ*P* (μ atoms)[3]	P : O
1	20	0	0	Air	30	Oxygen	1·26[4]	2·15	2·10	1·67
2	20	0·058	0	Air	30	Oxygen	2·20[4]	6·13	6·08	2·79
3	20	0·464	0	Air	30	Oxygen	2·20[4]	5·53	5·48	2·50
4	0	0·058	0	Air	30	Oxygen	0	0·05	—	—
5	20	0·464	0	Air	6·05	Oxygen	0·44[5]	0·82	0·80	1·80
6	20	0·464	0	Nitrogen	8·5	Cyt. *c*	0·23[6]	0·51	0·49	2·16
7	20	0	0	Nitrogen	8·5	None	0	0·01	—	—
8	20	0·464	0·001	Air	5·59	Cyt. *c*	0·23[6]	0·36	0·30	1·29
9	20	0·464	0·001	Air	7·88	Cyt. *c*	0·23[6]	0·50	0·40	1·76
10	20	0·464	0·001	Air	10·25	Cyt. *c*	0·23[6]	0·63	0·50	2·20
11	20	0	0·001	Air	5·59	None	0	0·06	—	—
12	20	0	0·001	Air	10·25	None	0	0·13	—	—
13	20	0·464	0·01	Air	8·16	Cyt. *c*	0·23[6]	0·24	0·22	0·98

[1] Experiments carried out between 23·2° and 24·7° and times adjusted to correspond to 24·2°, assuming $Q_{10} = 2$.
[2] Corrected for zero time control (0·162 μ moles).
[3] The following control values were used in calculating Δ*P*:
Nos. 1, 2, 3: value obtained in No. 4, namely, 0·05 μ mole.
Nos. 5, 6, 13: „ „ „ No. 7, namely, 0·015 μ mole.
No. 8: „ „ „ No. 11, namely, 0·06 μ mole.
No. 10: „ „ „ No. 12, namely, 0·13 μ mole.
No. 9: interpolated figure from Nos. 11 and 12, namely, 0·10 μ mole.
[4] Measured manometrically.
[5] Calculated from manometric measurement.
[6] Total ferricytochrome *c* added. Reduction was complete in 5·6 min

used, the phosphorus–oxygen ratio (2 molecules of cytochrome *c* taken as equal to 1 atom of oxygen) reached 2·20, 4·6 min. after all the cytochrome *c* was reduced. The single value obtained under anaerobic conditions was 2·16, obtained 2·9 min. after complete reduction. These values are minimal, since it is possible that higher ratios might have been obtained had the experiment been prolonged. These values may be compared with 1·80 for a short-time experiment and 2·50 in a long-time experiment, when oxygen was the final hydrogen acceptor. (The high concentration of cytochrome *c* used, $1{\cdot}5 \times 10^{-4}$ *M*, inhibited the phosphorylation slightly; a ratio of 2·79 was obtained with $1{\cdot}9 \times 10^{-5}$ *M* cytochrome *c*.) It is clear from the last line of the table that 0·01 *M* potassium cyanide inhibits phosphorylation considerably.

These experiments suggest that all the phosphorylation which occurs when α-ketoglutarate is oxidized by oxygen occurs in those steps of the hydrogen transfer reaction between substrate and cytochrome *c*.

Full details will be published elsewhere.

I wish to express my thanks to Prof. S. Ochoa for his advice and encouragement, and the Rockefeller Foundation for the opportunity to join Prof. Ochoa's Laboratory.

This investigation was aided by grants from the United States Public Health Service, the American Cancer Society (recommended by the Committee on Growth, National Research Council), the office of Naval Research and the Rockefeller Foundation.

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[2] Lehninger, A. L., and Smith, S. W., *J. Biol. Chem.*, **181**, 415 (1949).
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[5] Belitzer, V. A., and Tsibakowa, E. T., *Biokhimiya*, **4**, 516 (1939).
[6] Ochoa, S., *Nature*, **146**, 267 (1940); *J. Biol. Chem.*, **138**, 751 (1941).
[7] Hunter, F. E., *J. Biol. Chem.*, **177**, 361 (1949).
[8] Racker, E., *J. Biol. Chem.*, **167**, 843 (1947).

SUBJECTIVE JUDGMENTS

ON October 14, a meeting arranged as a private venture by a committee with Dr. R. G. Hopkinson (Building Research Station, Department of Scientific and Industrial Research) as secretary, was held at University College, London, to discuss subjective judgments. The attendance was large, the discussions were extremely lively, the views put forward were varied enough to satisfy the most determined opponent of uniformity, and altogether it was apparent that the problems raised are now attracting widespread and active attention both from the point of view of fundamental research and from that of the most appropriate methodology to be used in the study of a great many practical problems concerning human health, efficiency and comfort.

The morning discussion raised again the question of the measurability of sensation. After Sir Frederic Bartlett, who was in the chair, had opened the conference, Dr. D. R. Fry, of the Phonetics Department, University College, London, said that what is called 'measurement' in the case of sensation is the correlation of some aspect of the magnitude of a stimulus with some dimension of magnitude in the sensation. This is empirically possible. The magnitude usually, but not necessarily, adopted in the case of the sensation is a minimum perceptible difference in some assigned dimension; but as a subject can also compare different values of the same dimension and determine that in one case he has a value or magnitude which is a certain fraction of another, or a certain 'number of times' greater than another, there is ground for believing that quantitative sensation scales are feasible. It is not to be supposed that the dimensions of the stimulus are themselves a measure of the sensation, or that the number of discriminable dimensions of the sensation are necessarily equal to the number of physically measured dimensions of the stimulus. All that is needed is a certain consistency in the assigned relations of measured stimulus differences and sensation dimension differences, and these relations have to be treated by statistical analysis. Whether this is 'measurement' can be disputed. That it is both possible and useful is certain.

With Prof. R. C. Oldfield, University of Reading, some of the results of the impact of modern general machine theory upon the interpretation of sensory evidence came into the picture. The attempt to set up psycho-physical scales is one depending upon the empirical determination of a function of a physical stimulus variable which is such that its values correspond with judgments made by a subject in accordance with a given character. The early dualism of stimulus-sensation has broken down completely, for we have always to take into account the characteristic structure and internal variable state of whatever response system or device is set at work in our experiments. In the case of psycho-physical judgments, there seem to be three characters of the internal responding device which are remarkably persistent, though whether they are always in operation and what particular mathematical formulation of relationship they demand are still matters for determination. The first is an element having two positions of equilibrium. This may mean—and in most cases of psycho-physical judgment it usually does mean—"a non-linear transformation of the external variable", for example, o a logarithmic form, and such transformation may involve temporal derivations of the external variable. The second is a shifting standard, structurally built into the response system, and together with the first character, leading to a discontinuous 'all-or-none' expression of continuous change in the external variable. The third is an 'indifference range', which means that there is no apparent change of output or interpretation within experimentally determined limits of 'stimulus' variation, but that outside such limits marked change may suddenly appear. Whether the functional relations of a physical stimulus variable with a sequence of step-judgments based upon sensorial likeness and difference could be in any sense regarded as a 'measure' of sensation, Prof. Oldfield refused to say. But he did consider that their elucidation would show that the process of judging physical stimulus magnitudes could be regarded legitimately as fully amenable to quantitative treatment.

Dr. W. D. Wright asserted categorically that sensation magnitudes cannot be measured, for there is no form of yardstick that can be laid alongside them. Discrimination data cannot be used, because the magnitude of a discrimination may be dependent upon any of a number of variables, both external and internal, and nobody can know which are operating. Contrast-qualities cannot be used because all the results of trial are equally consistent with a number of different assumptions and we have no crucial way

of actually determining which is necessary. Thus no formally expressed relationship between stimulus and sensation has any validity; but this does not prevent the commonly adopted logarithmic scales of intensity from having great practical value.

This discussion was continued by Dr. R. W. Pickford, Prof. H. Hartridge, Mr. F. H. Brittain and Mr. J. M. Waldram, of the Research Laboratories of the General Electric Co., Ltd., and Dr. M. H. Pirenne.

Dr. Pickford was not much inclined to believe that sensations are, in any literal sense, measurable; but he gave illustrations to show that the commonly accepted correlations of stimulus and sensation variations are of operational value. In a written communication Dr. Pirenne expressed substantially the same view.

Prof. Hartridge showed that subjective observations carried out entirely independently by Granit and himself in the field of colour identification agreed remarkably closely, both in a qualitative sense and in regard to associated frequency values of the physical stimuli.

Mr. Brittain made an interesting suggestion of a physical model the operations of which might be regarded as strongly analogous to those of a human perceptual mechanism. This reinforced the view that no measure of input, or stimulus, could be valid which failed to pay attention to the character of the transforming and conducting processes internal to the responding system.

Mr. Waldram described some original and important illustrations of the use of stimulus-sensation correlations of a quantitative order.

Following this the discussion became general and open, and a large number of provocative and downright remarks were made. It is perhaps fair to say that there was exceedingly little agreement on any fundamental question, but almost complete agreement that even if sensations cannot be measured, they must be, and that the attempts which have been made are of great practical service.

In the afternoon meeting, the chair was taken by Dr. F. M. Lea, director of the Building Research Station (Department of Scientific and Industrial Research). The topic assigned was "The Subject as an Assessor of Sensation"; but the actual problems discussed concerned the methodology of experimental attempts to obtain reliable judgments based upon sensory evidence, and of their presentation in some numerical form, when the persons who make the judgments are also those who interpret the evidence.

Papers were presented by Dr. D. Richards, of the General Post Office Engineering Department, on the "Design and Analysis of Subjective Acoustical Experiments which involve a Quantal Response"; by Dr. R. Harper and Dr. G. W. Scott Blair (National Institute of Dairying) on "The Subjective Assessment of Deformable Materials and of Food Products"; by Dr. R. G. Hopkinson (Building Research Station) on "The Multiple Criterion Technique of Subjective Appraisal", and by Dr. E. C. Bate-Smith and A. S. C. Ehrenberg (Low Temperature Research Station, Cambridge) on "The Operation of Laboratory Taste Panels".

The general discussion was opened by Dr. N. H. Mackworth, who was followed by a considerable number of other nominated speakers, and these by an open debate which was carried on with very great vigour.

In the course of the afternoon, almost all the known psycho-physical methods were described, and illustrations of their alleged highly successful use were plentiful and varied. Dr. Hopkinson made a new and important point of method when he presented evidence to demonstrate that, if subjective judgments have to be made about the effects of a physical variable, more reliable results are secured if a limited number of criteria are used in succession instead of a single criterion.

Points arousing the greatest amount of difference of opinion were: (*a*) In discrimination experiments, is it better to allot control of the physical variables to the subject, or to the experimenter, or to a third person? (*b*) Do threshold determinations, whether absolute or relative, throw any light upon subjective assessments of complex groups of stimuli? (*c*) Do experts produce any better results from a general operational point of view than a random population, and are repeated experiments any better than a 'once-for-all' trial?

Two questions received inadequate notice: (i) The suggestion, made by Dr. Mackworth, that whenever possible performance criteria should be made to supplement direct subjective assessment received scant attention. This, in fact, is one form of the very difficult problem of the relationship between reliability and validation with which sooner or later everybody who makes use of subjective assessments must come to terms. But there was a persistent disposition to side-step this whole difficulty. (ii) The justification and types of statistical analysis and interpretation that are available, or should be considered, for dealing with arrays of data of the subjective assessment order were less considered than might have been expected.

In the end, Dr. Bate-Smith suggested that the conference seemed to be divided between those who say "You can't" and those who assert "We must". Perhaps, though he did not say so, he would favour some revision of the Emersonian dictum into a form such as:

> When Theory whispers low "You can't"
> Practice replies "I must".

And that is what most people seemed to think.

F. C. Bartlett

BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

SECOND RESEARCH PANEL MEETING

THE second meeting of the Research Panel of the British Gelatine and Glue Research Association, held at Beale's Restaurant, Holloway Road, London, N.7, on October 12, was attended by representatives of member firms, of research associations interested in the uses of gelatine and glue, and of the Department of Scientific and Industrial Research. The Research Panel meetings are intended to give an opportunity for interchange of scientific and technical information in the industry by the reading of papers followed by discussion.

In the morning session, Dr. J. H. Bowes, of the British Leather Manufacturers' Research Association, read a paper on "The Composition of Skin and the Changes Produced by the Action of Alkalis", describing, in the main, the work she has carried out in the past few years. Dr. Bowes first discussed the

composition of skin, pointing out that, although collagen is the principal constituent, the remaining substances may have an important influence on the conversion of collagen to gelatin as well as on the tanning properties of the skin. Elastin fibres, reticular tissue, keratin, muscle fibres, sweat and sebaceous glands all occur, and, in addition, polysaccharides are present in small amounts.

Turning to the composition of collagen, Dr. Bowes reviewed the work which she, together with Prof. A. C. Chibnall and his collaborators, have done on the amino-acid composition of collagen. The collagen was specially prepared with minimum modification of the skin used. The results showed that almost the entire amino-acid composition is accounted for, and that cystine and tryptophan are absent. Dr. Bowes pointed out the relation between the titration curve obtained with collagen and its composition, and considered the modifications which occur when collagen is treated with alkali for prolonged periods. The most important reaction is the hydrolysis of the amide groups, with the production of ammonia. In addition, the swelling of collagen under alkaline conditions cannot be adequately interpreted unless a loss of cohesion is postulated. A lively discussion followed the paper.

The afternoon session consisted of a paper by the director of research of the Association, Mr. A. G. Ward, on "Recent Studies of High Polymers in Relation to the Properties of Gelatine and Glue". Mr. Ward described the methods which have enabled quantitative data to be obtained for high polymers. The importance of the non-uniformity of the molecular weight of gelatin was stressed, and the significance of the various forms of average molecular weight was discussed. Experimental methods were described which have been successfully applied to gelatin, including osmotic pressure, surface pressure and the ultracentrifuge. Further aspects of high polymers which were outlined were the theory of degradation of polymer chains and the origin of rubber-like elasticity. Results already obtained for gelatin by such workers as Scathard, Pouradier and Ferry were described.

CHEMISTRY AT UNIVERSITY COLLEGE, DUNDEE

DURING the past three years the Chemistry Department of University College, Dundee, has been enlarged, renovated and re-equipped. On October 23 the new building was formally opened by Lord Burghley, rector of the University of St. Andrews. Sir James Irvine, vice-chancellor and principal of the University of St. Andrews, introduced Prof. N. V. Sidgwick, formerly professor of chemistry in the University of Oxford, who delivered an address. After the ceremony, Lady Burghley laid the foundation stone of a new science building which will house the Department of Electrical Engineering and the Department of Botany at Dundee.

The original chemistry laboratory at Dundee was built in 1883. It followed the German nineteenth-century style, having been modelled, like those of the Imperial College of Science and Technology, London, and of Owens College, Manchester, on Hofmann's laboratory at Bonn. At that time the Dundee laboratory ranked among the best-equipped in Great Britain, and was unique in its air-conditioning system which had been designed by Thomas Carnelley, the first professor at Dundee, along lines which have now become standard engineering practice. The building was added to in 1888, and the original plan was completed in 1905. Apart from some internal renovation in 1925, the Department has remained largely unchanged for nearly fifty years.

A storey has now been added, and the whole building has been completely renovated and re-serviced. The new floor provides two teaching laboratories, four organic chemistry research rooms and a glassblowers' workshop. The basement rooms vacated by the organic chemists have been converted to physical chemistry research laboratories. The two new teaching laboratories are each designed to accommodate thirty-two students comfortably; one will be used for teaching organic chemistry to second- and third-year students, while the other is shared between inorganic and physical chemistry teaching at the same level. The servicing of the building has been renewed and now includes all the usual piped services (gas, hot and cold water, compressed air and live steam) with a selection of electrical services (415 V. three-phase A.C., 240 V. A.C., 240 V. D.C. and 50 V. D.C.). The building is steam-heated and air-conditioned throughout.

In addition to the rebuilding, the Department has been extensively re-equipped. The research facilities have been extended to cover most important modern techniques in both physical and organic chemistry with the object of enabling problems to be studied using several different experimental methods. The work of the laboratory is at present concentrated mainly on the thermodynamics of solutions and adsorbed phases, electrochemistry, free-radical reactions and their relevance in polymer chemistry, acid-base catalysis, stereochemistry and problems of optical activity, together with general problems of reactivity of organic molecules. Furthermore, a full range of optical and spectroscopic techniques will shortly be available to supplement purely thermodynamic measurements. A well-equipped workshop and glassblowers' shop are making important contributions to these developments. It can now be fairly claimed that University College, Dundee, has a Chemistry Department which, for its size, is again among the best-equipped in Great Britain.

A conversazione was held on the afternoon of October 23, followed by the formal opening. Visitors were able to see a variety of research work in progress, demonstrations of the experiments used in the teaching laboratories, and a series of lecture demonstration models. Lord Burghley and the other guests, including representatives of Scottish universities and chemical industry, and past students, were welcomed by Prof. D. H. Everett, who referred to the difficulties which had been overcome in carrying through the reconstruction while the laboratory was in full use for both teaching and research. In a few words Lord Burghley declared the renovated building open.

Prof. Sidgwick began his address by mentioning the past holders of the chair of chemistry in University College, Dundee, since the foundation of the chair in 1882. Thomas Carnelley was professor for only six years and would, had he lived, have risen to a very high position in science. Percy Faraday Frankland, who in the field of chemistry was the distinguished son of an even more distinguished father, held the chair in Dundee during 1888–94; he then moved to Birmingham—and, incidentally, built there a labor-

atory closely resembling the one he left behind. He was followed by James Walker, much of whose best scientific work was done in Dundee before he moved to Edinburgh in 1908. Hugh Marshall's tenure of the chair was cut short by his untimely death in 1913. Alexander McKenzie, whose contributions to stereochemistry gained him world-wide reputation, was professor in Dundee during 1914–38. He was followed by W. F. K. Wynne-Jones (1938–47) and later by the present holder, Prof. Everett.

The increased facilities in Dundee for the teaching of chemistry and for research should benefit three classes of the community: the students in general, the research workers and chemical industry. Referring to the first group, Prof. Sidgwick stressed the purely educational value of chemistry and also the importance of teaching it as an experimental subject. Compared with the very simple apparatus available in his youth, that in use to-day might seem elaborate; but Prof. Sidgwick commented that, although really good men got valuable results with very limited accommodation, their work would have been still better had they had more space and better equipment. Modern techniques have opened up new fields of investigation which must be available to our students if they are not to be seriously handicapped in their research.

The relationship between universities and chemical industry was dealt with by Prof. Sidgwick in some detail. Up to the end of the past century the great majority of chemical manufacturers did not believe that science could help them; to-day almost every chemical firm has a research department. It is therefore of the greatest importance that adequate numbers of trained chemists should be provided by universities; but Prof. Sidgwick was apprehensive of the danger that, by offering large salaries, industry might now attract away many of the best research students and teachers and so cut down the supply of trained scientific workers.

On the closer link between industry and the universities, Prof. Sidgwick commented on the much more liberal attitude now adopted by an increasing number of firms. Money is now often given to laboratories and research students without restriction on the research problems to be engaged upon, and with complete freedom of publication. This is most satisfactory, but a difficult problem still remains in connexion with consultant work carried out by members of university staffs. While agreeing that this is beneficial both to methods of production and to the consultant's pocket, Prof. Sidgwick feared that it might also interfere with the teaching and research activities in the university. There seems to be no general solution of this problem, which is clearly one which has to be treated in each case individually.

D. H. EVERETT

MEMBRANE PERMEABILITY

AT the annual meeting of the Society of Leather Trades' Chemists, held during September 22–23 in the University of Leeds, the fourth Procter Memorial Lecture was delivered by Prof. E. K. Rideal, who chose as his subject "Membrane Permeability". Prof. Rideal, professor of chemistry in King's College, London, began by reminding his audience that natural membranes of animal origin contain proteins and lipoids; the bacteria contain mucoids and magnesium ribonucleate; and the plants, cellulose. The physiologist attempts to explore the nature of natural membranes *in vivo*, while the physico-chemical approach is to make models and find which one behaves most naturally. The monolayer technique reveals that membranes behaving as osmotic barriers must be multimolecular in thickness.

Three different types of membranes are recognized: the so-called sieve or capillary membrane, the lipoid or oil membrane, and the membrane consisting of a polymer. The problem of permeability has been attacked by direct passage, by osmotic and by E.M.F. methods. Each has contributed some information of value. Capillary membranes may consist of relatively large pores, as in aggregations of particles of different sizes; of laminar sheets, as in charcoal; or even of molecular pores, as in the zeolites.

The interest of the investigator is in tube areas and lengths, the latter involving a tortuosity factor. The Kozeny–Carman treatment of void fraction and surface area neglects in vapours the surface flow along the capillaries. In liquid flow, application of the Kelvin equation leads to the assumption of an immobile adsorbed layer of liquid. The work of Michaelis on the E.M.F. across sieve membranes has been reinterpreted by Meyer and Teorell in terms of two Donnan restraints on each side of the membrane and a number of fixed charges inside the membrane.

The permeability constant P, that is, the number of c.c. at N.P.T. of gas passing in 1 sec. through 1 sq. cm. of thickness 1 mm., is the product of the diffusion constant D and the solubility constant S. The former may vary as the membrane concentration of dissolved vapour changes. The permeability of polymer membranes is determined by the number of Eyring holes in the membrane capable of holding molecules of the penetrant, and the movement through the membrane is determined by the micro-Brownian movement of the non-crystalline chain segments of the polymer. Movement is thus a property of the polymer; the permeation process requires an energy of activation and is not a free diffusion; solute molecules suffer a large change in entropy when 'dissolved' in a polymer, that is, they are rather tightly held. The micro-Brownian movement of the chain segments likewise involves consideration of the ratio of fringe to micelle in the 'fringed micelle' type of polymer. Some penetrants can peptize the micelles; others cannot do so. If such a polymer membrane is expanded by solvent or plasticizer, it passes over into the capillary-type, which has already been discussed.

The oil type of membrane seems to bear the closest analogy to natural membranes, which may consist of a lipoid-like material held in an open network of cellulose, or in the form of a lipoid lipo-protein complex mosaic. The reactions at the interface between the membrane boundaries and the homogeneous phases can be studied by the monolayer technique; here the control of the mechanism of chemical reactions by surface tension changes, as well as the phenomenon of penetration, are all-important. While the electrometric work of Beutner and his colleagues represents, in the main, non-equilibrium conditions, it is important to study the rate of transfer of solute across the boundaries by direct as well as electrochemical means. The data obtained in this way bear a close resemblance to those natural cell walls which have been investigated.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Effect of Dextran of Various Molecular Sizes on Erythrocyte Sedimentation Rate

When dextran is mixed with blood an increase in erythrocyte sedimentation rate, due to aggregation of red blood corpuscles, is observed. In Sweden[1,2] and in Great Britain[3] it has been shown that this effect is greater with larger molecules (at least within the range of molecular weight 100,000–600,000), while with dextran of molecular weight less than about 60,000 there is no appreciable increase[3,4] in erythrocyte sedimentation rate. We have carried out experiments to establish these relationships on a quantitative basis.

The method involved mixing known concentrations of dextran in 0·9 per cent sodium chloride with fresh defibrinated human blood from normal volunteers. The final concentration of red blood corpuscles in the mixtures was maintained at definite values, in these experiments corresponding to a hæmatocrit of 30 per cent, and the concentration of serum was 35 per cent of the supernatant fluid. Erythrocyte sedimentation was observed in vertical Wintrobe tubes, 100 mm. in length and 3 mm. internal diameter, at a temperature of 25° C., readings being taken every five or ten minutes for at least ninety minutes. The maximum rate of sedimentation[5] was derived graphically from these data. The relative viscosity and specific gravity of each dextran–serum mixture and the specific gravity of each blood, serum and dextran–serum mixture (making calculation of erythrocyte specific gravity possible) were determined respectively by microviscometer[6] and the copper sulphate method of Van Slyke[7]. The maximum rates of sedimentation were then corrected to a standard relative viscosity (1·8), and a standard specific gravity difference between erythrocytes and serum mixture (0·066), the result being referred to as 'corrected maximum sedimentation velocity'.

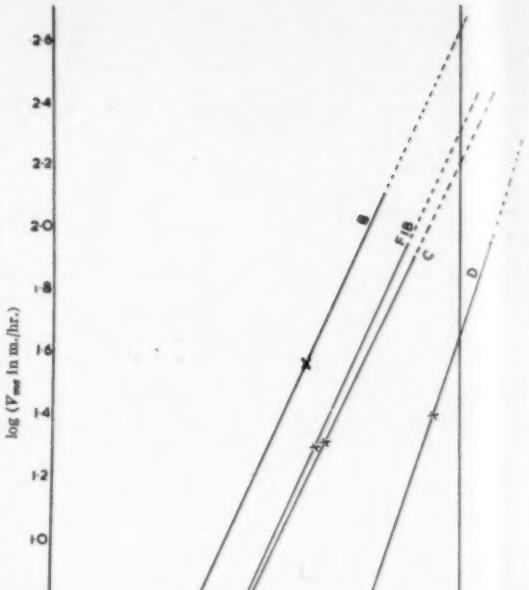
$$\text{Corrected maximum sedimentation velocity} = V_{mc}$$
$$= \text{observed maximum rate} \times \frac{\text{observed relative viscosity}}{1{\cdot}8} \times \frac{0{\cdot}066}{\text{observed specific gravity difference between cells and serum}}$$

The dextran used was prepared by solvent (acetone)-precipitation from special hydrolysates of *Leuconostoc mesenteroides* cultures.

The range of molecular weight within each preparation was kept as small as practicable. The samples were characterized by calculation of intrinsic viscosities from determinations of relative viscosity at two concentrations between 0·5 and 1·5 per cent in each case. An indication of the mean molecular weights can be derived from the intrinsic viscosities on the basis of the ultracentrifuge studies of Ingelman and Halling[4].

Table 1

Preparation	Intrinsic viscosity	Mean molecular weight
B	0·54	700,000
C	0·36	220,000
D	0·28	124,000



Relationship between corrected maximum sedimentation velocity and concentration of macromolecules added to constant erythrocyte, serum–saline mixtures (30 per cent erythrocytes in each case). *B*, *C*, *D* indicate dextrans *B*, *C*, *D* respectively, and *Fib* human fibrinogen

V_{mc} was then determined in duplicate for at least four concentrations of each dextran preparation. It was discovered empirically that a linear relationship existed between log (V_{mc}) and log (concentration of dextran) (see graph).

Statistical analysis shows these regressions to be highly significant, with no significant departure from linearity.

Clearly, $\log (V_{mc}) = \log K + b \log (\text{conc.})$, and b is independent of the molecular weight of dextran used, corresponding approximately to 2·17 in these experiments. K, which corresponds to the corrected maximum sedimentation velocity in 1 per cent of the dextran preparation, increases with the molecular weight of the dextran preparation employed. Equally satisfactory linear relationships were obtained with mixtures of the dextran preparations, K in this instance being a resultant of those of the respective dextrans employed in proportion to their concentrations.

Similar experiments have been carried out using fibrinogen solutions in place of dextran (see graph). With equivalent erythrocyte concentrations, the values of b obtained with fibrinogen are similar to those shown for the dextran preparations, K being close to that found for dextran *C*.

The raised erythrocyte sedimentation rate found in various diseases depends in varying degree upon a rise in fibrinogen and on other asymmetric macro-

Table 2

Substance	Concentration range	No. of observations	Regression (b)	σ_b	Log K (y when log $x = 0$)	$\sigma_{\log K}$
Dextran *B*	0·170–0·565 gm. per cent	32	2·147	± 0·072	2·61	± 0·038
Fibrinogen	0·158–0·752 gm. per cent	10	2·197	± 0·113	2·29	± 0·073
Dextran *C*	0·170–0·700 gm. per cent	6	2·046	± 0·156	2·19	± 0·170
Dextran *D*	0·382–1·360 gm. per cent	8	2·406	± 0·190	1·63	± 0·037

molecules in patients' sera[8,9]. The quantitative evaluation of these different factors will be the subject of a full communication.

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Effect of Aureomycin on *Trichomonas intestinalis hominis*

During studies of aureomycin in human amœbiasis, we observed a remarkable side-effect in those patients who simultaneously harboured *Trichomonas intestinalis*. Before treatment, these flagellates were present in small numbers only; but they increased considerably after the administration of 3–4 gm. of aureomycin. This increase continued during treatment lasting seven to ten days and was not dependent on the consistency of the stools before or during treatment. In three out of the eight cases observed the increase was enormous; examination of these stools gave the impression of a pure culture of *Trichomonas*. Though it is known that *Trichomonas intestinalis* may appear in large numbers in the convalescent stage of bacillary dysentery (Manson-Bahr), it is less frequently observed in amœbic dysentery. We consider the regularity of the increase in eight cases and the enormous numbers occurring in three cases as particularly noteworthy.

Two possible explanations are suggested for this increase: (1) aureomycin may have caused a change in the bacterial flora of the intestine, making this milieu more congenial for the propagation of *Trichomonas*; (2) aureomycin may have exerted a specific growth stimulation on the flagellates. Such an effect was not observed on *Chilomastix* or *Lamblia*, which remained uninfluenced by this drug.

Studies on the effect of aureomycin on the intestinal flora will be reported shortly, and we are continuing to study the influence of this drug *in vitro* on *Trichomonas intestinalis*.

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Effect of 2,4-Dinitrophenol on Osmoregulation in Isolated Kidney Slices

Stern, Eggleston, Hems and Krebs[1] reported that slices of a number of guinea pig tissues swelled in isotonic solutions under anaerobic conditions. They suggested that the fluid balance of living tissues is not determined merely by physical forces, but by a mechanism dependent upon the supply of energy. Robinson[2] found that rat kidney slices swelled to a similar extent, mainly on account of an increase in the volume of intracellular water, when respiration was inhibited by small concentrations of cyanide. This swelling was reversed when the oxygen uptake recovered, as hydrogen cyanide distilled out of the medium. The water content of the slices varied inversely with their oxygen consumption over the whole range from normal respiration to complete inhibition. The amount of osmotic work required to maintain the water content of the slices as a steady state was calculated, and found to be proportional to their oxygen uptake. It was therefore suggested that the intracellular fluid was hypertonic, and that the normal volume and internal hypertonicity of the cells were maintained by active transport of water outwards across the cell membranes at the expense of energy directly derived from oxidation.

	No. of expts.	Respiration (μl./mgm./hr.)	± S.D.	Total tissue water %	± S.D.
Normal medium	44	4·2	0·4	77·5	0·8
" + M/200 cyanide	8	0·4	0·15	84·2	0·9
" + 10^{-4} M 2,4-dinitrophenol	13	4·6	0·5	82·6	1·0

In recent experiments, 10^{-4} M 2,4-dinitrophenol was added to the isotonic medium in which adult rat kidney slices were respiring in Barcroft manometers at 38·5° C. In this solution the slices swelled almost as much as they did when their respiration was inhibited by cyanide, though their oxygen uptake, if anything, was slightly increased. The total water content of the slices, which serves as a measure of swelling, is shown in the accompanying table. Respiratory rates are expressed in μl. of oxygen per hr. per mgm. initial moist weight of tissue. The smallness of the effect of 2,4-dinitrophenol upon the oxygen uptake may be explained by the observation of Dodds and Greville[3] that 2,4-dinitro-*o*-cresol did not increase the oxygen uptake of rat kidney slices

in a phosphate-buffered medium such as was used in the present experiments, though it greatly increased respiration in a medium containing bicarbonate and lactate.

The dissociation of active osmoregulation and respiration by a concentration of 2,4-dinitrophenol which has been found to uncouple phosphorylation from oxidation[4] suggests that osmotic work performed by the cells in maintaining their normal water content is carried out through the mediation of phosphate bond energy.

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Production of Stippled Erythrocytes *in vitro*

THE punctate basophilia in erythrocytes occurring in association with lead poisoning has been interpreted in different ways and its origin still remains unknown. Since the various interpretations have been thoroughly dealt with in several text-books and monographs[1–4] they will not be repeated here. It must be emphasized, however, that disagreement exists as to whether punctate basophilia originates in the immature erythroblasts of the bone marrow[5] or in the circulating red cells. Neither is it known whether stippled erythrocytes merely represent altered reticulocytes or polychromatic, that is, young erythrocytes.

No studies appear to have been carried out to detect whether the direct action of a lead medium upon erythrocytes *in vitro* may cause basophile stippling. For this purpose we suspended normal rabbit erythrocytes in plasma from rabbits suffering from severe lead poisoning.

The experimental rabbits were poisoned with litharge (PbO) by daily intravenous injections of 0·25 gm. of litharge (suspended—partly dissolved—in 10 ml. water at 32° C.). Their blood picture was followed by hæmoglobin determinations and by counting the erythrocytes, leucocytes, reticulocytes, and basophile stippled cells. Reticulocytes were counted in moist preparations, after staining with a 0·1 per cent solution of Brilliant Cresyl Blue. Stippling was determined partly in May–Grünwald-stained smears, partly by the method described by Helge Lund[6]. In the course of five to eight days, the poisoned rabbits developed stippled cells in considerable numbers (10–20 per cent). Like previous workers[2], we found that, although the poisoning persisted, the number of stippled cells decreased again, returning to normal values shortly before death (Table 1). No relation could be found between the number of reticulocytes and stippled cells. Neither does the degree of poisoning appear to bear any relation to the number of basophile cells.

Table 1

Experimental period (days)	Hb %	Erythrocytes	Reticulocytes (‰)	Stippled cells (‰)
0	92	5·12	23	5
2	87	5·00	23	27
4	84	4·88	29	68
6	84	4·32	27	133
8	79	4·12	38	205
10	81	4·26	33	151
12	77	4·09	30	42
14	72	4·00	39	20
16	found dead			

Table 1 shows the fluctuations in the number of reticulocytes and of stippled cells during the course of lead poisoning in a rabbit receiving an intravenous injection of 0·25 gm. of litharge daily.

When the rabbits had received the poison for eight days, 20 ml. of blood was drawn from a vein. The above-mentioned values were determined, after which the blood was centrifuged (15 min., 1,500 r.p.m.). To the plasma so obtained, washed blood cells from a normal rabbit were added and the specimen was placed in a water-bath of 37° C. for four hours. During this process, 'Carbogen' was passed through the samples. This provided them with oxygen and prevented sedimentation. At the end of four hours, reticulocytes and stippled cells were counted.

Control experiments were carried out with normal erythrocytes and normal serum. Table 2 gives the results of five experiments.

Table 2

Normal erythrocytes suspended in: Plasma from 5 normal rabbits		Plasma from 5 rabbits poisoned with litharge		Blood of the rabbits with lead poisoning	
Stippled cells (‰)	Reticulocytes (‰)	Stippled cells (‰)	Reticulocytes (‰)	Stippled cells (‰)	Reticulocytes (‰)
7	19	139	21	205	39
5	27	112	25	170	43
3	25	100	20	138	27
6	31	56	39	78	25
6	20	107	25	151	38

It will be seen from the experiments, all of which point in the same direction, that stippling may be induced in normal cells cultivated *in vitro* in a medium which conditions stippling *in vivo*.

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Influence of Histamine and Acetylcholine on Nerve Block due to Procaine

IN a previous communication[1], experiments on nerve-muscle preparations were reported, showing that histamine is able to restore conduction in a nerve, blocked by procaine, even though procaine is still present. These experiments have now been confirmed by action potential studies. In a typical experiment the central part of a frog ischiadicus nerve, from which the connective tissue sheath had been carefully removed, was placed in a phosphate Ringer solution containing 0·05 per cent procaine hydrochloride. The solution was adjusted to *p*H 7·3

in the presence of 6·5 per cent carbon dioxide. The nerve was stimulated with a break shock every second, and every spike was photographed. Total block occurred after 9·6 min. Then, without moving the nerve from the electrodes, this solution was replaced by a similar solution, containing 0·05 per cent procaine hydrochloride and 0·5 per cent histamine dihydrochloride, also adjusted to *p*H 7·3. Recovery began almost immediately, and in 1·9 min. the spike area was 72 per cent of the value at the onset of the experiment. This seemed to be the maximal effect.

In exactly the same way, a solution of 0·05 per cent procaine hydrochloride, containing 0·5 per cent acetylcholine and a trace of eserine[2], is able to restore a block caused by 0·05 per cent procaine hydrochloride. However, this effect seems to occur more slowly. In a typical experiment the spike disappeared in 6 min. with procaine, and a maximal recovery was reached in 25 min. with procaine plus acetylcholine. The area of the spike was then 57 per cent of the starting value.

The fact that the action potential is not completely restored indicates the possibility that not all the fibres are capable of being restored. During recovery, the action potential often shows a double peak which indicates the presence of fibre groups of different conduction velocity. When recovery is maximal, the spike again shows only one peak. It seems to be of importance that the nerve should be used soon after removal from the animal. Further studies on these problems are in progress.

Note added in proof. Since the above communication was written, a letter by Drs. Cabrera and Thompson[3] has appeared. They state that the deblocking effect of histamine reported by Bárány and Nordqvist is due only to a change in *p*H. The experiments have therefore been repeated with improved apparatus, where it is possible to measure *p*H in the nerve bath proper. The deblocking action was independent of any shift of *p*H.

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Chloromycetin Resistance in *E. coli*, a Case of Quantitative Inheritance in Bacteria

Drug resistance in bacteria has been investigated genetically in several cases, since Demerec began with penicillin resistance in *Staphylococcus aureus*[1]. The proposal to distinguish two classes of drug resistance—those in which the top level of resistance can be obtained in a single step, and those in which it can be acquired only gradually—has clearly a practical importance; its theoretical meaning has not been entirely elucidated, since genetical analysis has several limitations in bacteria. In fact, while mutational patterns are open to investigation in most cases, crossings can only be regularly undertaken, as in Lederberg and Tatum's original discovery[2], in a few strains of *E. coli*. In one of these, *E. coli* *K*-12, some work on the genetics of drug resistance has been carried out, the most extensive investigation relating to streptomycin. Full resistance in *E. coli* is developed in a single step[3,4].

Besides resistance, dependence is known, whereby some resistant mutants fail to grow in absence of streptomycin. Full streptomycin-resistance and dependence[4,5] seem to be due to a single locus (or closely linked loci). Further, Lederberg introduced resistance to azide[6] as a genetic marker; here a single step brings about a moderate degree of resistance, and the determining factor has been mapped, not only in this laboratory but also independently in two other laboratories, and found to be about midway between V_1 and *TL* on the 'chromosome map' of *E. coli* *K*-12. Nitrogen mustard resistance was found to be gradual or abrupt in increase in different experiments, only a moderate degree of resistance being acquired, which made a detailed analysis difficult. In *E. coli* *K*-12 nitrogen mustard resistance is not accompanied by higher resistance to radiations, as in the case of *E. coli* B.

Completely 'gradual' increase of resistance has been found in the case of chloromycetin in *E. coli* *K*-12. Selecting for chloromycetin resistance by serial transfers in liquid cultures containing increasing concentrations of the drug (on a geometric scale), a rapid and relatively smooth increase of resistance is observed. Starting from a tolerated level of 5–10 μgm./ml., as is usual with strains derived from the original *E. coli* *K*-12, levels of resistance as high as 1,280 μgm./ml. (which is not far from the solubility limit of chloromycetin) can be obtained. The increase in resistance is twofold or lower, on the average, at every transfer. Resistance is relatively stable on repeated subculture in the absence of chloromycetin.

The smoothness of increase of resistance might constitute a *prima facie* case for non-genetical adaptation; if, on the other hand, adaptation is genetical, a relatively large number of genes should be found affecting chloromycetin resistance, assuming that it is to be accounted for by known genetical mechanisms.

A cross was made between a *W* 677 strain (T-*L*-B_1-*Lac*$_1$-V_1^r *Mal*$_1$– *Gal*$_1$– *Xyl*– *Ara*– *Mtl*–) which had been grown with 640 μgm./ml. chloromycetin in broth, and a fully sensitive 58–161 strain (*B*–*M*–). Crosses were made with the usual technique introduced by Lederberg and Tatum[2]. By this technique, recombinants are selected out of a mixture of parental cells using 'fixed' recombination markers, in this case capacity of growth in absence of given growth factors. Strain 58–161 can grow in the absence of threonine, leucine, vitamin B_1, which are needed by *W* 677 for growth; strain *W* 677 can grow in absence of biotin and methionine which are needed for growth by 58–161. Plating the mixture of the two strains on minimal medium, where such growth factors are not supplied, parental cells will not develop, while recombinants of the right type can develop into visible colonies. The two strains differ by a number of other markers, lactose fermentation (absent in *W* 677, present in 58–161), reaction to virus T_1 (V_1^r indicating resistance in *W* 677, while 58–161 is sensitive), etc., as indicated by the other symbols.

Such differences can be used as 'free' recombination markers in that they are not directly selected for or against in the minimal agar plates, and their segregation in the recombined colonies is used to build a 'chromosome map'[7]. The relative order of the genes which have been 'mapped' satisfactorily, and which are relevant for this and other crosses conducted during the present work, is as follows:

B_1-(B,M)-V_8-Lac_1-V_1-Az-(T,L), where V_8 refers to virus T_8 resistance, Az to azide resistance.

Recombinants between the chloromycetin-resistant W 677 and sensitive 58–161 showed a scatter from full sensitivity to nearly full resistance, the resistance of each recombinant being roughly proportional, on the average, to the length of the chromosome segment which—as could be inferred from recombination markers—given recombinants got from the resistant parent. A closer analysis shows one and possibly two loci for resistance in the segment between BM and Lac; one locus at least between Lac and V_1—there is evidence that other loci, too, must take part in building full resistance. These data are therefore consistent with the hypothesis of many loci with cumulative action.

First-step resistants, obtained by both plate and test-tube selection methods, were analysed in crosses of sensitive with resistant and resistant with resistant, and they showed a clear-cut segregation of sensitivity or resistance, within experimental error. Mapping loci of first-step resistance, the locus most frequently met so far was closely linked to V_8. In this way, a cross with four free markers between BM and TL (fixed recombination markers) was made, involving chloromycetin resistance, V_8, Lac and V_1, giving a relatively satisfactory test of linearity of the chromosome region between BM and TL. First-step resistants were also found which gave no resistant recombinants when crossed to sensitive, probably because of close linkage with fixed recombination markers (BM in this case). The interactions in resistance between different loci are under investigation at present. In fact, this case seems to offer unusual possibilities of a detailed analysis of the interactions between genes in quantitative inheritance. The stability of the drug is a factor of no little importance in facilitating quantitative work with chloromycetin.

The K-12 strains used in this research have been kindly sent by Dr. J. Lederberg. One of us (G. A. M.) has been supported during this work by a grant from the Rockefeller Foundation.

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Modification of the Biochemical Responses of the Immature Pullet to Œstrogen by means of Dietary Aureomycin

The effects and roles of dietary supplements containing growth-factors and antibiotics have recently excited widespread interest among poultry nutritionists. This interest prompted us to examine the effect of adding aureomycin to the diet upon the biochemical responses of the sexually immature pullet to œstrogen, and with reference to serum calcium and serum riboflavin in the first instance. It is well known that the increase of serum riboflavin evoked by œstrogen is closely related to the increase in serum calcium[1], and hence to the concurrent increases in serum phosphoprotein and phospholipid. These responses may be secondary to the effects of œstrogen on liver activity and function[2]. Furthermore, Hertz, Tullner and Dhyse[3] have shown that the magnitude of the response of serum riboflavin to œstrogen is, within limits, related to the level of riboflavin in the diet, a point which has been noted also in this laboratory[4].

In the light of these considerations, it seemed that aureomycin might conceivably influence the response of serum riboflavin and serum calcium to œstrogen in one or other of the following ways:

(*a*) By reducing fixation or destruction of dietary riboflavin by the intestinal flora, while not modifying the responses of serum calcium, etc. In this case, the serum riboflavin values corresponding to given serum calcium-levels should be higher in œstrogenized birds receiving aureomycin than in similarly treated birds not receiving aureomycin.

(*b*) By reducing fixation or destruction of growth-factors by the intestinal flora generally, or possibly by reducing production of deleterious substances, in such a way that the liver response to a given dose of œstrogen is enhanced. In this case, both the serum calcium and serum riboflavin of œstrogenized pullets receiving aureomycin should be higher than in similarly treated birds not receiving aureomycin.

	Group I	Group II	Group III	Group IV
No. of pullets	6	6	6	6
Av. initial live-weight (kgm.)	0·64	0·62	0·65	0·61
Av. final live-weight (kgm.)	0·90	0·87	0·90	0·86
Total dosage of œstradiol benzoate (mgm.)	nil	nil	6 × 1·0	6 × 1·0
Total dosage of testosterone propionate (mgm.)	nil	nil	6 × 0·5	6 × 0·5
Aureomycin hydrochloride (mgm./lb. food)	nil	20	nil	20
Oviduct weight (gm.)	0·12	0·11	12·7	12·9
Liver weight (gm.)	18·0	15·9	20·5	20·9
Serum calcium (mgm./100 ml.)*	11·3	11·1	34·7	49·0
Serum riboflavin (μgm./ml.)†	0·03	0·04	1·03	1·85

* Difference between Group I and Group II not significant. Difference between Group III and Group IV significant at $P = 0·05$ (least significant difference = 10·2).
† Difference between Group I and Group II not significant. Difference between Group III and Group IV significant at $P = 0·05$ (least significant difference = 0·702).

Accordingly, four groups each of six immature cross-bred pullets (New Hampshire ♂ × Barred Plymouth Rock ♀) aged seven weeks were placed at random in individual cages and assigned at random to four different treatments (see table). The percentage composition of the diet was as follows: maize meal, 30; barley, 20; oats, 10; wheat, 10; soybean meal, 16; fish meal, 3; meat meal, 3; skim milk powder, 2; dried brewer's yeast, 2; dehydrated alfalfa, 2; limestone flour, 2; rock phosphate, 1·0. To each 100 lb. of this diet was added ½ lb. salt, 11·4 gm. manganese sulphate, 0·5 gm. niacin, 3 gm. riboflavin (Merck), 0·25 gm. pantothenic acid and 100 gm. fish oil (2,400 units vitamin A, 400 units vitamin D_3).

Groups I and III received the above diet. Groups II and IV received the same diet supplemented with 20 mgm. crystalline aureomycin hydrochloride (Lederle) per lb. The food consumption was main-

tained equal as between all birds. The experimental period lasted twelve days. The œstrogen was given intramuscularly in six equal doses on alternate mornings.

The results show that the inclusion of aureomycin in the diet enhanced the response of *both* serum calcium and serum riboflavin to œstrogen. The effect was about the same as would have been the effect of injecting *c.* 10 mgm. œstradiol benzoate instead of 6 mgm., and the relation between serum calcium and serum riboflavin was not apparently disturbed.

It seems possible from this experiment that the addition of antibiotics to a reasonably adequate diet may modify its nutritional effects in such a way that the responsiveness of the pullet to parenteral œstrogen is enhanced. It follows that the responsiveness of the pullet to endogenous œstrogen may likewise be modified by inclusion of antibiotics in its diet. Further experiments would be necessary before attempting to relate this effect of aureomycin to the supply of vitamins B_{12} available for protein-synthesizing functions[5] in the liver.

We are indebted to the National Research Council of Canada for a grant in aid of this work, to Messrs. Schering Corporation for gifts of hormones and to Dr. T. H. Jukes, of Lederle Laboratories, and Dr. N. Nikolaiczuk for a gift of aureomycin hydrochloride.

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Folic Acid as a Growth-Factor for the Rat

The recent publication by Aschkenasy-Lelu and Aschkenasy[1] of their findings on the effects of folic acid on growth and blood composition in the young rat on a synthetic diet with or without adequate protein has prompted us to record a note on some early observations made on folic acid as a growth-factor. As soon as crystalline folic acid became available for biological research in 1946, an experiment was planned to investigate the effect of folic acid on the growth of rats receiving a synthetic diet. Weanling rats of the black-and-white Lister Institute strain were given at 28 days of age a diet consisting of:

Vitamin-free casein	20 per cent
Sucrose	60 ,, ,,
Hardened arachis oil	12 ,, ,,
Lard	3 ,, ,,
Salt mixture (McCollum 185)	5 ,, ,,

with 0·02 ml. cod liver oil daily and 1 ml. of a solution of B vitamins containing, per ml.:

Vitamin B_1	10 μgm.	Vitamin B_2	10 μgm.
Riboflavin	40 ,,	Pantothenic acid	100 ,,
Biotin	1 ,,	Nicotinic acid	1 mgm.
Inositol	1 mgm.	*p*-Aminobenzoic acid	1 ,,
Choline chloride	3 ,,		

Folic acid was administered separately in daily doses of 0, 0·5, 1·0, 2·0, 4·0 or 8·0 μgm. A positive control group of rats was given a crude liver extract in a daily dose equivalent to 6 gm. original liver.

In preliminary tests an extracted casein, which was of a dark yellow colour, possibly due to overheating in the drying process, was used and the animals did not grow satisfactorily except in the group receiving crude liver extract. The animals had poor coats and some showed reddish-brown staining of the fur and tail. No macroscopic evidence of liver or kidney damage was found when the animals were killed after seven weeks on the diet. Afterwards, more satisfactory samples of casein were obtained and all animals showed good weight increases during the first four weeks on the diet, with a decline in later weeks. The rats remained in good general condition throughout. The results of a typical experiment are given in the accompanying table.

Weight Increases of Rats Receiving a Purified Diet with Graded Doses of Folic Acid

Dose of folic acid (μgm.)	Number and sex of rats ♂	♀	Average weekly weight increases (gm. in 4-week period)	Average weekly weight increases (gm. in 7-week period)
0	4	4	15·60	12·46
0·5	4	4	15·75	11·94
1·0	3	5	15·38	12·55
2·0	2	6	16·03	12·38
4·0	2	6	15·47	11·95
8·0	4	4	17·69	13·45
Liver extract	3	5	21·19	14·40

When the differences between the average growth-rates for the different groups were compared by Fisher's *t*-test, no significant differences were found except in the group having liver extract, which grew better than any of the others. This result was repeated in later tests, and it thus appeared that addition of up to 8 μgm. folic acid daily to the synthetic diet did not affect the weight increase in young rats. It was apparent from the preliminary tests that the nature of the casein component of the diet was of considerable importance in a highly purified diet.

These results are of interest in view of the relation which Aschkenasy-Lelu and Aschkenasy reported between the protein-level in the diet and the response to a daily dose of 50 μgm. folic acid. The numbers of rats in their experiments were small; but it seemed that only very small and irregular increases in average growth occurred when the dose of 50 μgm. folic acid was given with a diet containing 15 per cent casein. When there was 7 per cent of casein in the diet, administration of folic acid appeared to depress growth. Even with 20 per cent of casein in the diet for the present tests the growth response was poor if the casein was not of good quality. It would seem that folic acid is not an essential growth-factor for rats, and that other more important growth-factors present in liver extracts are required to supplement a purified diet. Further details of the study of growth factors are in the course of publication.

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Nature of the Milk-Ejection Process

THE fact that extracts of the posterior lobe of the pituitary gland will cause expulsion of milk from the mammary glands of lactating animals has been known for some time[1,2]. The suggestion that the oxytocic factor is involved in normal milk let-down was made by Ely and Petersen[3], though Turner had proposed a theory of milk ejection earlier[4] and with Cooper[5] presented evidence for the existence of a separate milk-ejection hormone. This evidence was based on the use of a lactating rabbit as an assay animal, and showed that the milk-ejecting activity of whole pituitrin is greater than that of purified oxytocin for a given oxytocic activity, and that the purified pressor preparation is more active than it should be for its oxytocic content.

Using the lactating sow as an assay animal and milking her by machine, I have confirmed the observations of Turner and Cooper on the milk-ejecting activity of commercial purified pressor preparation. Through the generosity of Dr. du Vigneaud, a sample of purified oxytocin assaying 500 oxytocic units per mgm. was made available for milk-ejection assay. This sample had been prepared by the method of Livermore and du Vigneaud[6]. It had a milk-ejecting potency equal to its oxytocic activity. The assay was based on two criteria, namely, the volume of milk ejected and the duration of the let-down action. These results point to oxytocin being the let-down hormone. However, they also raise the problem of why commercial preparations of pressor hormone with an oxytocic content stated by the makers to be less than five per cent should have a milk-ejecting activity of about five times their oxytocic activity.

The mode of action of the milk-ejecting hormone has in the past been assumed to be due to its acting on smooth-muscle fibres in the mammary gland. MacFarlane[7] and Richardson[8] have demonstrated the existence of myoepithelial cells so distributed in the mammary gland as to provide a mechanism by which the milk-containing alveoli can be squeezed and the contents expelled into the collecting ducts. These cells are also seen to run along the walls of the small ducts. As these ducts will be closed by the pressure of the surrounding filled alveoli prior to milking, their contraction or attempted contraction should result in an opening of the lumen on the duct. That such an opening may occur is suggested by the following evidence:

(1) When let-down occurs in the cow there is a sudden large rise in gland cistern pressure. This is followed by a small fall as the hormone is dissipated. Should milking be attempted, say, ten minutes after let-down, only 60 per cent or so of the normal milk yield will be obtained unless there is another release of hormone. The fall in pressure in the unmilked cistern is much smaller than it should be if the retained milk is held, due only to the alveoli relaxing and 'sucking back' the expelled liquid. These observations have been made by a number of workers as well as during work at this laboratory.

(2) In his studies on intramammary pressure at this laboratory, Mr. Phillips[9] has shown that during the period of action of the let-down hormone, the milk cistern of the cow is connected to a constant-pressure source (such as contracting fibres around the alveoli). When the hormone goes out of action, the connexion to this constant-pressure source is broken.

(3) If, after let-down is evoked, sterile saline is run into the cistern of a cow to a pressure above that due to normal let-down, the injection of pituitary extract causes a fall in pressure. No change or a rise in pressure would be expected if the only action of the milk let-down hormone is the compression of the alveoli.

(4) In the case of the sow, which has no gland cistern, the flow of milk stops suddenly when the hormone is dissipated, almost as if a valve mechanism shuts when a certain threshold is reached.

In the light of this evidence, it is suggested that when the let-down hormone acts on the mammary gland it not only causes a contraction of the myo-epithelium around the alveoli, so causing an increase in pressure within the latter, but also causes an opening of the small ducts due to the tightening of the longitudinal myoepithelial structures surrounding them. This causes a fall in duct impedance and a consequent rapid flow of the milk into the large ducts and the gland cistern.

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Milk Ejection following Electrical Stimulation of the Pituitary Stalk in Rabbits

CONSIDERABLE indirect evidence exists[1] for the involvement of the posterior pituitary gland in 'let-down' or ejection of milk. Experiments were performed to find the effect of electrical stimulation of the pituitary stalk on the mammary glands in six lactating rabbits. After overnight separation from their litters, the animals were anæsthetized with ether, and a single teat-duct was cannulated and connected to a kymographic volume-recording system. A glass-insulated platinum wire electrode with 1 mm. bare tip mounted on a stereotaxic instrument was used for stimulation. A standard stimulus of 1 min. duration was adopted with 1·0 volt, 50 cycles sine-wave alternating current.

Following stimulation, milk was seen to flow up the cannula after a latent period of about 25 sec., reaching a peak at 90 sec., and thereafter gradually subsiding to the original level over 4–7 min. The volume of milk ejected was 0·5–1·5 c.c., representing approximately 1/48 of the total ejection volume, since there are six ducts in each teat. Successive ejection responses were of diminishing magnitude, but as many as three responses could be elicited in a period of 30 min. Intravenous injection of 200 mU. posterior pituitary extract gave similar ejection responses with a latent period of 10–15 sec.

These results offer strong support for posterior pituitary mediation of 'let-down'. They provide no clue to the mechanism initiating the response; but recent evidence[2] suggests that the suckling stimulus activates the neurohypophysis in the normal un-

anaesthetized rabbit. Experiments are in progress to study the effect of electrolytic lesions in the supra-optico-hypophysial tract on 'let-down' in this species.

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Variation of the Somatic Chromosome Number in Man

The necessity of stressing the importance of chromosomes in the organization of plants and animals, and their decisive role in inheritance, caused O. Hertwig in 1918 to formulate the 'law of constancy of chromosome number', which implies that all cells of a given organism contain the same somatic number of chromosomes. A great number of observations have, however, shown that this concept is in need of revision. Especially in insects[1,2] and in plants[3], it has been established that certain cells and even whole tissues may represent different degrees of polyploidy.

It has been proposed that another type of variation occurs in the somatic chromosome number of man. Disregarding authors whose cytological technique has been insufficient to warrant exact conclusions, we may take Karplus[4] and Andres and Jiv[5] as the first to produce evidence that the somatic cells in human embryonic tissues contain variable, mostly aneuploid, chromosome numbers.

That these findings, which are undoubtedly valid in the light of our present observations, have been completely overlooked in the cytological literature is, however, easy to understand. First, it seems at first sight to be impossible to bring them into agreement with the known rules of heredity and gene action. Secondly, human embryonic tissues are rather difficult to fix satisfactorily. The figures in the earlier papers are consequently rather unconvincing. Hence studies on human chromosomes as well as on other animals have been made mostly on germ-line cells, which naturally must contain the chromosome number characteristic of the species. Thirdly, chromosomes have been more extensively studied in plants and lower animals. Since in these—except for occasional polyploidy—the somatic cells seem to contain a constant chromosome number, it has naturally been inferred that the same must be true of the higher animals also. A final blow to attempts to propose a variation in the somatic chromosome number in man was given by the authority of Kemp[6], who maintained that they were due to faulty observations.

We were led to study the somatic chromosomes in man through our studies on the cytology of human cancer tissues[7–9]. As normal comparison material the uterine epithelium in its proliferation stage was chosen. It was found that the cells in this tissue had chromosome numbers showing a wide range of variation. Timonen[9] counted the chromosome number in a thousand cells. The numbers varied between 4 and 100, the highest peak lying at 20–25 chromosomes and another much lower at 45–50 chromosomes. Measurements of nuclear volumes gave values which were in good agreement with the varying chromosome numbers.

To discover whether the same condition obtains in other human tissues, embryonic tissues were studied cytologically. Our material consisted of various tissues of fourteen human embryos aged six to twenty-four weeks. It was found that all the embryonic tissues studied, including skin, brain, liver, intestine, cartilage, and bone marrow, had chromosome numbers varying from 12 to polyploids, the chromosome numbers most frequently encountered obviously lying between 20 and 30. No special number was characteristic for any kind of tissue. Whether or not the peaks varied between different tissues cannot be decided from the present material. Fig. 1 represents the 20 somatic chromosomes from a brain cell in an eight-weeks embryo, while Fig. 2 illustrates a somatic metaphase from uterine epithelium with 41 chromosomes.

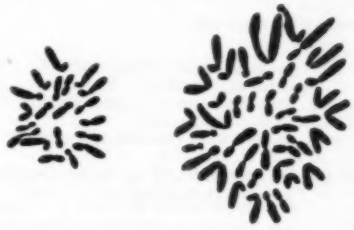

Fig. 1 Fig. 2

Fig. 1. Somatic metaphase plate with 20 chromosomes from a brain cell of an eight-weeks embryo. (× 3,000.)
Fig. 2. Somatic metaphase plate with 41 chromosomes from the uterine epithelium. (× 3,000.)

What the actual mechanism underlying the variation in the somatic chromosome number is, is not clear, since very early stages have not as yet been studied. Whether the lagging chromosomes seen especially in the anaphase stages are able in themselves to bring about this phenomenon remains so far an open question.

The most obvious problem is, however, how the variation in the somatic chromosome number is to be reconciled with the fact that heredity and differentiation in man obey the same laws as in those organisms in which every somatic cell contains the constant diploid chromosome complement. To account for this, we must assume that the whole human organism, or at least the whole tissue, acts as one unit. Let us assume an original cell with the complete chromosome complement necessary for the development of the organism, and that a tissue arises from this in which the cells contain different numbers and combinations of chromosomes. (By what means this differential distribution is effected is not of importance in this connexion.) If we suppose that every individual chromosome has divided the same number of times, the relative number of the different chromosomes in the tissue remains the same as in the original cell. For such a tissue in which the chromosomes are distributed differentially between the cells to act similarly to a tissue in which every cell contains the same number of chromosomes, we must assume that the chemical and physiological interaction between the cells is much closer than in lower animals. In the lower organisms every cell would be a relatively independent unit, whereas the working unit in man would be the whole organism.

We suggest tentatively that the same type of variation in the somatic chromosome number will be found to be characteristic of warm-blooded animals in

general. It does not seem impossible that it is just this property which determines the difference in the organization of plants and lower animals on one hand and of the warm-blooded animals on the other. We may in this connexion recall, for example, the great capacity for regeneration of plants and lower animals as compared with higher animals, and the occurrence of both sex and other mosaics in plants and insects and their absence in warm-blooded animals.

Our thanks are due to Prof. A. Turunen, head of the Women's Clinic of the University of Helsinki, for the opportunity of carrying out the present study. A more extensive account of these observations and their theoretical implications will be published elsewhere[10].

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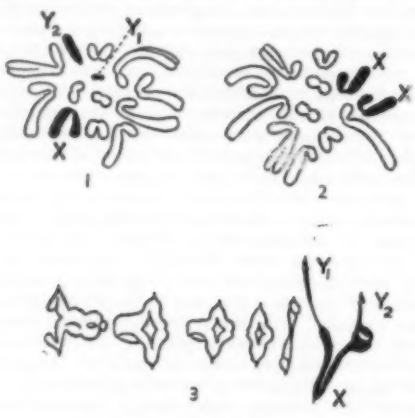
Multiple Sex Chromosomes in the Marsupials

DURING the past thirty years, some twenty species of marsupials have been examined cytologically. In all of them, a typical XY sex-chromosome mechanism has been reported. We have recently re-investigated the potoroo (*Potorous tridactylus*), a common species of rat-kangaroo in Tasmania. In the spermatogonial mitoses, the male shows thirteen chromosomes, whereas the female shows twelve in ovarian mitoses (Figs. 1 and 2). The chromosomes of the female can easily be arranged in homologous pairs, one pair (the X-chromosomes) being conspicuous by their long, nearly median, centromere constriction. In the male, ten chromosomes can be paired, but three have no similar partners. These are the X, with a long submedian constriction, the smallest of the set (Y_1), and an acrocentric (Y_2). The last two chromosomes are not represented in the female. In accord with these observations, five bivalents held together by from one to five chiasmata and a trivalent are formed at the first division of meiosis in the male (Fig. 3). The trivalent is made up of the X, pairing in one of its arms with Y_1, and in the other arm with Y_2. Orientation on the spindle is always such that Y_1 and Y_2 are directed to one pole, and the X to the other pole. Two types of sperm are produced, a male-determining type with seven chromosomes, and a female-determining with six. The sex-determining mechanism is, thus, of the $XY_1Y_2 : XX$ type.



Magnification, 2,000

In the prophase stages of meiosis, the Y_2 and its homologous arm in the X behave similarly to the autosomes and usually form two typical chiasmata. The other arm of the X-chromosome, like Y_1, is strongly heterochromatic, being condensed into an irregular sphere at earliest diplotene. At later diplotene this arm is seen to be made up of two parts, the distal pairing segment being more condensed than the intercalary unpaired region. This behaviour is characteristic of the X-chromosomes of other marsupials that have been investigated[1]. It is thus probable that the aberrant mechanism in the potoroo has arisen by translocation between the X-chromosome and an autosome with loss of a centromere.

These results are based on the examination of three specimens, a male from Sorell in southern Tasmania, and a male and female obtained in Hobart. The species has previously been investigated by Altmann and Ellery[2] in animals obtained from Tasmania. They interpreted their observations as showing a typical XY mechanism. It is, perhaps, possible that two sex-determination mechanisms exist in this species. However, since their XY bivalent corresponds in size to the smallest bivalent of our material, this seems unlikely.

It is at present impossible to say how widespread multiple sex-chromosome mechanisms are in the marsupials. As pointed out by Darlington[3] and more recently by Matthey[4], Agar's[5] results on *Macropus ualabatus* (= *Wallabia bicolor*) are probably to be interpreted as showing the existence of a multiple mechanism in this species. Indeed, the X-chromosome seems to have the same long centromere constriction which is visible in the potoroo. We interpret Agar's figures as showing that the female wallaby has ten chromosomes; and the male eleven, of which three form a trivalent at meiosis as in the potoroo. It is probable that a similar mechanism may also exist in the insectivore *Sorex araneus*, Bovey (cited in Matthey[4]) having described a trivalent at meiosis in the male. The chromosome number in the female of this species is, however, unknown.

We wish to thank Mr. A. G. Lyne for assistance in this investigation. The Fauna Board of Tasmania kindly gave us permission to take specimens of this protected animal. One of us was in receipt of a Commonwealth Research Scholarship.

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Height to Node Ratio of Jute Plants

In an earlier communication[1], it was pointed out that, at the fruiting stage, the ratio of the height to the number of nodes of the two varieties of mung (*Phaseolus aureus* Roxb. Syn., *Phaseolus radiatus* Linn.) plants, sown at different times of the year, lies always between 2·2 and 2·9, and that the total height and the number of nodes of the two varieties gradually became similar as the sowing was delayed from August until October.

Calculations made from results obtained while studying the effect of sowing-time on the growth and development of two species of jute, *Corchorus capsularis* Linn. (type D.154), and *C. olitorius* Linn. (type Chinsura Green), sown at an interval of thirty days from April to June (in case of the latter species, however, the first sowing was not done), in replicated plots in the field, showed very similar results. The final observations and measurements, as well as the ratio of the height to the number of nodes, are shown in the accompanying table.

Date of sowing	*Corchorus capsularis*			*Corchorus olitorius*		
	Height, *H* (cm.)	No. of nodes (*N*)	*H*/*N*	Height, *H* (cm.)	No. of nodes (*N*)	*H*/*N*
April 1	314·17	81·33	3·86	—	—	—
May 1	331·25	88·30	3·75	360·67	107·66	3·55
May 31	257·75	70·33	3·66	269·66	72·66	3·71
June 30	193·00	55·00	3·50	188·70	51·33	3·67

The ratios of height to number of nodes with reference to the different time of sowing lie between 3·50 and 3·86 for *C. capsularis* and 3·35–3·71 for *C. olitorius*. The difference between the highest and the lowest ratios is 0·36 in both cases, whereas for mung[1] it was observed that the difference was 0·7 in both varieties. The ratio is correlated with the time of sowing only in the case of *C. capsularis*. The heights and the number of nodes of the two species, as in the case of mung[1], gradually became almost similar at the later sowings. It has further been observed that the range of variation with regard to the ratio is greater during the early stages of growth of the plants than at the later stages.

This work was done at the Botanical Laboratory, Presidency College, Calcutta. A detailed paper has already been sent elsewhere for publication.

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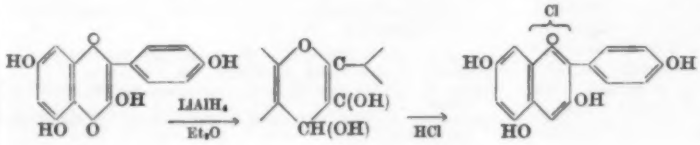
Conversion of Flavonols into Anthocyanidins

Qualitative experiments with a wide range of γ-pyrones show that they are reduced by lithium aluminium hydride to γ-pyranols, which afford pyrylium salts on treatment with acids.



Anthocyanidins are produced in this way from the appropriate flavonols. Thus kæmpferol yields pelargonidin chloride, which was readily isolated, crystallized and identified.

The process is a general one and naturally works well with methoxylated flavones, though protection of hydroxyl groups is not essential; it is also applicable to the reduction of xanthones to xanthydrols (thence to xanthylium salts) and to other γ-pyrones.

The advantage of this method resides in the fact that pinacol-like coupling of the molecules is avoided. Thus a paper chromatogram of the reduction product of kæmpferol showed that the pelargonidin was uncontaminated by related pigments. The feasibility of reduction of flavonols should provide a new resource in the study of natural products because the flavylium salts have very characteristic properties

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Preparation of Bicholestatriene from Cholesterylacetate

In a recent communication in *Nature*, Hafez[1] has described the isolation of a yellow bicholestatriene from the mixture of products obtained by the action of N-bromosuccinimide on Δ^4-*i*-cholestadiene. A compound of similar, if not identical, nature is also occasionally obtained as a by-product of the preparation of 7-dehydrocholesterylacetate from cholesterylacetate and N-bromosuccinimide according to the procedure of Bernstein *et al.*[2].

In a typical experiment, 5 gm. of cholesterylacetate was dissolved in 60 c.c. of petroleum ether (b.p. 60–70°). After the addition of 2·5 gm. N-bromosuccinimide, the mixture was refluxed with stirring and illumination from an *RSP*-2 'Photospot' lamp placed 5 cm. below the flask. The reaction was accompanied by the evolution of some hydrobromic acid. After four minutes, 2·55 c.c. of *s*-collidine was added to the reaction mixture, which was then cooled to room temperature and filtered. The filtrate was concentrated *in vacuo*, and the oily residue dissolved in 30 c.c. of benzene containing 1·5 c.c. of *s*-collidine. The solution was refluxed for twenty minutes and then cooled and washed successively with ice-cold aqueous solutions of hydrochloric acid and sodium carbonate and with water. Removal of the solvent *in vacuo* afforded a dark oily residue which was dissolved in petroleum ether and chromatographed on a silica gel column. Elution with benzene–petroleum ether (1 : 1) gave 400 mgm. of a yellow material which after two crystallizations from benzene-ethanol melted at 241–244°; $[\alpha]D^{25°} = -200°$ (found: C, 88·54; H, 11·54 per cent; molecular weight, 728; calculated for $C_{54}H_{82}$: C, 88·70; H, 11·30 per cent; molecular weight, 731). The ultraviolet absorption spectrum of this hydrocarbon in *n*-hexane shows maxima at 254 ($E = 12{\cdot}400$), 262 ($E = 13{\cdot}400$), 350 ($E = 40{\cdot}200$) and 368 ($E = 44{\cdot}500$).

It appears most likely that this hydrocarbon is identical with that described by Hafez, and that the mechanism of its

formation does not necessarily involve the *i*-steroid structure.

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Change with Temperature of the Heat of Wetting of Dry Cellulose in Water, and its Bearing on the Specific Heat of the Adsorbed Water and of the Swollen Cellulose

THE heat of wetting of dry standard cellulose in water was measured at temperatures between 0° C. and 40° C. The cellulose and the experimental technique were those described previously[1]. The heat of wetting decreases with the rise of temperature as shown by the following values, which represent the means of several experimental results at each temperature :

Temperature	Heat of wetting (cal./gm. dry cellulose)
0° C.	11·84
10	11·51
20	11·01
25	10·80
30	10·70
40	10·14

The decrease appears to be linear in the range tested, and amounts to about 0·042 cal./degree/gm. cellulose.

The heat of wetting represents the decrease in the heat content ($-\Delta H$) of the 'dry cellulose–water' system through the wetting process. The variation of the change of heat-content with temperature represents the difference between the heat capacity of the system before and after wetting as given by Kirchhoff's equation :

$$d(\Delta H)/dT = \Delta C_p.$$

$d(\Delta H)/dT$ here is positive. It means that the heat capacity of the system after wetting (swollen cellulose-adsorbed water) is more than its heat capacity before wetting, that is, more than the sum of the heat capacity of the dry cellulose and that of the water it can adsorb. Such increase in the heat capacity of the system resulting from wetting may be due to some change either in the water, on being taken up by the dry cellulose, or in the cellulose itself, on swelling, or due to a change in both.

As to the water, it may be suggested that adsorption causes some depolymerization of the liquid. This may take place either directly by the splitting of the adsorbed polymerized molecules on the surface of the cellulose, or indirectly by the selective adsorption of the simple molecules, and thus disturbing the equilibrium between the simple and the polymerized molecules of the liquid. Depolymerization of liquid water seems to cause an increase in its specific heat, as suggested by the thermal measurements by Koch[2]. These show that the specific heat C_p of the liquid decreases with the increase of pressure at constant temperature. At the same time, it is reasonable to think that the increase of pressure would cause an increase in the degree of polymerization. Again, Koch's measurements show that C_p increases with the rise of temperature, while this would decrease the degree of polymerization. Thus it may be concluded that the adsorbed water has a higher specific heat than that of ordinary liquid water due to a smaller degree of polymerization.

As to the cellulose, its swelling is a process analogous to depolymerization, since it represents a partial separation of the cellulose micelles. Thus it may be expected that the swollen cellulose would also have a higher specific heat than that of dry cellulose.

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Stability of Complex Salts of Bivalent Metals

IN the study of absorption spectra of inner complex salts of acetylacetone with bivalent metals, we have found the absorption maximum shifts towards longer wave-lengths in the following order :

Acetylacetone	273 mμ	alcoholic solution
$Zn(acetylacetone)_2$	280 ,,	
$Co(acetylacetone)_2$	282 ,,	
$Ni(acetylacetone)_2$	294 ,,	
$Cu(acetylacetone)_2$	296 ,,	

The above absorption bands of complex salts are due to the acetylacetone molecules co-ordinated to the central metal, and the displacement of the position indicates the degree of deformation or polarization of ligand molecules. In other words, the copper complex salt, which shows the largest displacement, combines with acetylacetone most firmly and is most stable. The chemical properties, such as stability against alkali, thermal decomposition, exchange of central metal with other metals in the aqueous solution, etc., also show the remarkable stability of the copper complex salt. The manganous and ferrous complexes are very unstable and easily oxidized to the trivalent state. Arranged in order of stability, the series is, therefore,

$$Cu > Ni > Co > Zn > Fe, Mn.$$

Recently, several studies on the stability of complex salts of bivalent metals with salicylaldehyde[1,2], sodium salicylaldehyde sulphonate[3], *o*-formylnaphthoxide[3] and β,β′,β″-triaminotriethylamine[4] have been published. These studies gave the nearly identical stability series of bivalent metals, namely,

$$Zn < Cu > Ni > Co > Fe > Mn.$$

Our results are also in accord with these results, and add another example to the stability series of bivalent metals.

A part of these results were published in Japanese (*J. Chem. Soc. Japan*, **69**, 70 (1948)).

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Analysis of DDT Derivatives by Reversed-Phase Paper Partition Chromatography

For the purpose of studying the metabolism in insects of a radioactive bromine analogue of DDT, $(Br^*C_6H_4)_2$ $CH.CCl_3$ (I), a method was required for the separation and estimation of (I) and the possible metabolites, $(Br^*C_6H_4)_2$ $C : CCl_2$ (II), and $(Br^*C_6H_4)_2$ $CH.COOH$ (III), on the micro-mole scale. It was important that the method itself should not bring about any decomposition of unchanged (I).

We have analysed mixtures of these compounds labelled by bromine-82 by reversed phase[1] uni-dimensional paper partition chromatography as follows: 100 × 2·5-cm. strips of Whatman No. 1 filter paper were drawn once through a bath of ether containing 2·5 per cent by weight of 'Vaseline', drained, and dried. The mixture for analysis (for example, in benzene), which contained not more than 50 μgm. of each component, was applied to the top of the strip. When the volume of solution was unavoidably large it was applied drop by drop, each drop being allowed to evaporate before applying the next one, so that the 'Vaseline' was not washed away from the zone of application. The mobile phase consisted by volume of 80 per cent ethanol, 15 per cent water and 5 per cent '880'-ammonia and was allowed to descend the strip in the usual way.

Under these conditions, (I), (II) and (III) moved with R_F values of 0·44, 0·35 and 0·75 respectively. In some instances there was an unexplained slight but similar shift in all the R_F values. When dealing with unknown mixtures, therefore, a known weight of (I) or (II) was sometimes added as a 'marker'. The separated components were located radiometrically by cutting the strips into equal sections and mounting them below a thin end-window Geiger-Müller counter. Provided the sections are small and suitably mounted, it may be reasonably assumed that the geometrical distribution of the compound will be the same for each section. The weight of compound in each section is negligibly small compared with the weight of the material of the section itself, so that self-absorption of the β-radiation assayed depends only upon the density of the strip and is constant for each section.

On this basis the total weight w of a particular component is proportional to the sum of the net rates of count (corrected for decay, dead-time losses, etc.) of the sections associated with a particular peak, that is, $w = k\Sigma a$, where a is the corrected net rate of count for each relevant section; k depends upon the specific activity of the original component and upon the overall counting efficiency. It has been found convenient in practice to determine k by surveying a chromatogram run with a known weight of compound of known specific activity. In the case of a 100-γgm. mixture of (I) and (II), the separated peaks of which run closely, it was estimated that less than 5 per cent of the mixture remained unresolved in 22 hr. No isotope exchange between different compounds could be detected when a mixture containing radioactive (I) and inactive (II) and (III) was resolved by this method.

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A Method for Large-scale Separation of Amino-acids on Filter Paper

For quantitative determinations of amino-acids separated on filter paper, it is often desirable that the spots should contain a larger quantity of substance than is as a rule possible to achieve with unaffected resolution. A one-dimensional technique in which the substance to be analysed is applied along a line across the paper has been described by Yanofsky, Wasserman and Bonner[1]. I have successfully applied the following two-dimensional technique for separating comparatively large quantities of amino-acids in bacterial hydrolysates.

About 5 mgm. or more by dry weight of the hydrolysate was applied as twenty spots along a line 12 cm. from the short side of a Whatman No. 4 filter paper (46·114 cm.). To make the size of the original spots less than 5 mm. in diameter, a condition essential for good separation, the application of the amino-acid solution was effected by means of an 'Agla' micrometer syringe. This was operated by a synchronous electric motor to yield 0·01 ml. in 12 min. To facilitate evaporation, a stream of air was passed over the site of application at the same time as it was slightly heated. When all the twenty spots had been applied, the short side of the paper nearer to them was immersed in a glass trough holding a mixture of butanol – water – glacial acetic acid (5 + 5 + 1 parts) and the paper was left hanging in a chromatographic box at 5° C. for 85 hr. The low temperature was chosen to reduce esterification. After 85 hr., the front had run off the paper into a roll of filter paper stapled to the bottom of the sheet as described by Miettinen and Virtanen[2]. After drying at 40° C., the paper was cut parallel to its short side into sheets carrying suitable groups of amino-acids. The position of the cuts was determined by comparison with standard amino-acids that had run parallel to the unknown substance, then cut off from the main sheet and developed with ninhydrin.

To concentrate the amino-acids, now localized as bands across the sheets, they were eluted with distilled water travelling downwards over the papers at right angles to the direction in which the butanol front had been run. Care was taken to ensure that the front did not pass a horizontal line 4 cm. above the end of the sheet. To facilitate accurate control of this position, a couple of stainless steel electrodes were mounted at this level. They were connected up in a circuit for measuring the resistance, and when the front changed the conductivity of the paper the trough was emptied by means of an electrically controlled tap and a signal was given. The paper was dried at 40° C. and the elution process repeated. The amino-acids were now accumulated along the line where the front had been stopped. The sheets carrying tyrosine, valine, methionine and phenylalanine, *iso*leucine, and leucine respectively were then run against the direction of the elution with *tert.*-amyl alcohol in diethylamine vapour according to the method recommended by Work[3]. The sheet carrying the rest of the amino-acids was run in the same direction with phenol in an ammonia atmosphere after the topmost part of the paper had been sprayed with phenol to give the front a start over the fastest-running amino-acids.

The technique described yields quantities of the different amino-acids which can, for example, easily

be determined as soluble copper complexes by the method described by Woiwod[4].

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Quantitative Paper Chromatography of Amino-acids

INDEPENDENT observations made in this Laboratory, during recent months, serve to confirm and to extend the findings recently reported by Fowden and Penney[1], concerning the factors causing loss in the quantitative estimation of amino-acids by paper chromatography. Since our experiments have been carried out under somewhat different conditions from those of these authors, and further, since we are not in complete agreement on all points, we feel it is desirable to record our findings.

The chief differences in our experimental conditions are the use of: (1) Whatman No. 54 filter paper instead of Whatman No. 4; (2) phenol/water (4 : 1), that is, unsaturated, and with the absence of ammonia; (3) lutidine/water (3 : 1) as a second experimental solvent; (4) an initial temperature of 95–100° for drying chromatograms, the heating current being switched off from the commencement of drying.

Effect of using washed filter paper upon amino-acid recovery. In agreement with Fowden and Penney, we have found that the blanks on untreated filter paper are high and variable, and that treatment of the paper with dilute alkali reduces the blanks very considerably. However, we have not found a simple alkali-washing to be sufficient to give consistent blanks and good recoveries. The use of a more thorough treatment gives a paper with improved properties, as is indicated in Table 1.

Table 1

Amino-acid chromatographed	Quantity applied (μgm.)	Recovery on paper (per cent) Washed with alkali	Boiled with alkali
Glycine	10	74, 86	96, 96, 97·5
Leucine	10	73, 63	84, 84, 100

The specially treated paper was boiled with four successive portions of 1 per cent alkali and then with water until free from alkali. The necessity for such treatment would seem to indicate the presence in the paper of ninhydrin-reacting materials other than ammonia[2].

Effect of heat in the absence of solvent on the recovery of amino-acids from filter paper. In the range of temperature investigated by Fowden and Penney, heat has practically no effect on the recovery of amino-acids. Our work has shown, however, that at higher temperatures (150°) considerable losses occur.

Table 2

Amino-acid	Quantity applied (μgm.)	Average recovery (in μgm.) on drying for 15 min. at 50°	100°	150°
Alanine	10	10·7 (9)*	10·1 (8)	7·5 (8)
Glycine	10	9·7 (14)	9·6 (14)	7·2 (11)
Leucine	15	14·8 (5)	14·9 (6)	12·2 (6)

* Figures in brackets indicate the number of determinations averaged.

Effect of heat in the presence of solvent on amino-acid recovery. Filter paper was spotted with alanine, glycine and leucine, treated with aqueous phenol and dried for 15 min. At 150° C. losses were considerable; at 100° they were still appreciable, except in the case of glycine; while at 50° the recovery was satisfactory.

Table 3

Amino-acid	Quantity applied (μgm.)	Average recovery (in μgm.) at 50°	100°	150°
Alanine	10	10·7 (2)*	8·5 (5)	4·5 (3)
Glycine	10	10·2 (4)	9·5 (6)	6·6 (4)
Leucine	15	14·5 (6)	12·1 (9)	6·3 (3)

* Figures in brackets indicate the number of determinations averaged.

Recoveries of amino-acids from one-dimensional chromatograms. These are shown in Table 4.

Table 4

Amino-acid chromatographed	Quantity applied (μgm.)	Solvent	Recovery in (μgm.)
Alanine	10	phenol	9·3, 9·9
Alanine	10	lutidine	8·5, 9·8
Glycine	10	phenol	8·7, 9·6, 10·2, 9·6, 9·6, 9·75
Glycine	10	lutidine	9·6, 10·7, 10·9
Leucine	15	phenol	14·4, 14·7, 12·7, 12·6, 12·6, 15

It is to be noted that the results do not indicate that the behaviour of glycine differs notably from that of other amino-acids.

In all cases amino-acid contents of papers were determined by the method of Moore and Stein.

The above data are recorded with the permission of the South African Council for Scientific and Industrial Research.

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History of Chromatography

ALL those interested in the history of chromatography, including the authors of the present communication, have hitherto accepted the claim that M. S. Tswett was the discoverer of this extremely fruitful method of analysis. A detailed survey of the early literature of adsorption in petroleum technology recently initiated by one of us (H. W.)[1] strongly suggests that, despite the powerful influence which his experiments have undoubtedly had on later generations, Tswett has, in fact, received considerably more credit than is his due.

So early as 1897, D. T. Day[2], pursuing investigations of the methods by which natural petroleum is formed and transformed, showed that if crude petroleum is forced upwards through a column of powdered limestone some fractionation occurs and the oil which first emerges is thinner and lighter in colour than that which follows. A similar commercial process had, indeed, been devised some ten years previously for the petroleum industry by C. Engler and M. Boehm for the bleaching of oil and the pro-

duction of petroleum jelly. The oil to be bleached was passed through six batteries of adsorbents each containing about one kilo of charcoal. Similar adsorbers were described by other contemporary authors[4,5]; but such processes are, of course, essentially what Fink[6] has called adsorptive filtration rather than true chromatography. Day, however, carried his experiments further and on August 20, 1900, exhibited in Paris, at the First International Petroleum Congress, hydrocarbon fractions which he had isolated by differential adsorption on a column of fuller's earth. The full text of Day's lecture to the Congress[7] is not now available; but abstracts and comments upon it were published by various authors who were present[8-10]. Petroleum from the top of the column, in which the crude material rose by capillary action, approximated to a first distillate; from the centre a heavier oil was obtained, and from the bottom a semi-solid petroleum jelly. From the contemporary accounts it is quite clear that Day was well aware of the possibilities and the importance of his method for the analysis of hydrocarbon mixtures of all kinds. At a dinner given on the evening following the lecture, the president, B. Dvorkovitz[11], referred to Day's discovery as outstanding, saying that like all great discoveries "it looks simple—in fact is simple—but it requires much previous thought, patience, and perseverance". Day did not realize his hopes of sufficiently perfecting his method within a few months to isolate pure individual hydrocarbons, though over a period of years he and his co-workers effected many successful fractionations[12-16], and he did not recognize the supreme importance of adsorption in the process until much later, looking upon it at first as chiefly a capillary effect, such as was then known to occur in the wicks of lamps. Nevertheless, it is difficult to regard his method as anything but a crude form of chromatography. L. Zechmeister's opinion[17] that Day "might in favourable circumstances have been successful in the elaboration of chromatographic procedures" seems, therefore, rather less than just, for Day conforms closely to that author's definition of chromatography as "those processes which allow the resolution of solute mixtures by selective fixation and liberation on a solid surface or support, with the aid of a fluid streaming in a definite direction".

It is not Day alone, however, who may claim to have anticipated Tswett. C. Engler was present at Day's lecture in Paris, and at once proceeded with E. Albrecht to elaborate the method in experiments[8] which seem to have been completely overlooked. They accelerated the rate of flow through their column by using a large head of liquid. They collected, at fixed intervals, successive fractions emerging from the top of the column and distinguished them by determination of such physical properties as density, viscosity and boiling-point. In fact, they undoubtedly formed a liquid chromatogram, a technique normally ascribed to Koschara some thirty-five years later. They carefully investigated the mechanism of the process by using a specially built column containing ports at intervals along its length so that samples could be withdrawn for analysis. They did not restrict themselves exclusively to hydrocarbon mixtures but stressed the applicability of the method in other fields, and they ascertained the physical nature of the process.

Russian petroleum chemists *inter alia* also took up the method. Herr[18], for example, fractionated Baku petroleum by percolation through fuller's earth, forming, like Engler, a flowing chromatogram. He introduced optical methods for identifying various fractions, and showed that aromatic fractions could chromatographically be separated from aliphatic ones. Phyälä[19], too, carried out effective chromatographic analyses of Baku petroleum, though, like Day, he was inclined to attribute the separation to capillary forces rather than to adsorption.

It now seems clear that by the time Tswett performed his chromatographic isolations of plant pigments there already existed a considerable literature on the subject, in English, French, German and Russian, published in well-known journals by chemists of repute. Furthermore, a form of chromatography had been described in detail at the First International Petroleum Congress in Paris and there singled out as a particularly important discovery. It is therefore highly probable that Tswett, who had travelled widely and was by no means parochial in his interests, was aware of what had already been done. That he made no acknowledgment is not altogether surprising and need not reflect upon him, for, as a botanist, his interest in chemistry was quite clearly limited to using it as a means of attaining his own ends. For example, a botanist using a new dye to stain sections would not normally refer to the chemical research involved in the synthesis of the dye. Furthermore, his work, as is well known, attracted little attention at the time and there was, therefore, no occasion for him to give any detailed explanation of how he developed his method. When interest in chromatography revived about 1930 it was again at first used for the isolation of natural pigments and it was therefore natural for the workers concerned to refer back to the work of Tswett in the identical field rather than to the earlier work in the less familiar field of petroleum technology. Nevertheless, it appears that the discovery of chromatography ought properly to be associated with the names of Day and of Engler and Albrecht rather than with that of Tswett, and that this year, therefore, marks the fiftieth anniversary of the discovery. Further particulars on the work of Day are being published elsewhere[1].

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[18] Herr, W. E., *Petroleum*, **4**, 1284 (Berlin, 1908–9).
[19] Phyälä, E., *Petroleum*, **5**, 1525 (Berlin, 1910).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Saturday, December 9

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS (at Neville Hall, Newcastle-upon-Tyne), at 2.30 p.m.—Prof. Granville Poole: Inaugural Address.

Monday, December 11

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. J. B. S. Haldane, F.R.S.: "Inverse Probability".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Reynolds Hall, College of Technology, Manchester), at 5.30 p.m.—Prof. Sir Robert Robinson, O.M., F.R.S.: "Chemistry of Penicillin" (Ramsden Memorial Lecture).*

Tuesday, December 12

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.8), at 5 p.m.—Scientific Papers.

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. Ir. Hoog: "The Development of Catalysts in Industrial Chemistry".

ILLUMINATING ENGINEERING SOCIETY (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Dr. B. P. Dudding: "The Development of the Tungsten Lamp".

INSTITUTION OF THE RUBBER INDUSTRY, MANCHESTER SECTION (at the Engineers' Club, Albert Square, Manchester), at 6.15 p.m.—Dr. C. M. Blow: "The Testing and Grading of Raw Rubber".

INSTITUTION OF WORKS MANAGERS, WEST MIDLAND BRANCH (at the Grand Hotel, Birmingham), at 7 p.m.—Mr. T. Dean: "Material Handling".

SHEFFIELD METALLURGICAL SOCIETY (at the Grand Hotel, Sheffield), at 7 p.m.—Mr. G. M. Gemmill: "Problems in the Development of Creep Resisting Steels".

Wednesday, December 13

ASSOCIATION OF APPLIED BIOLOGISTS (in the Mining Lecture Theatre, Imperial College, Prince Consort Road, London, S.W.7), at 11.15 a.m. and 2.10 p.m.—General Meeting and Scientific Papers on "Some Aspects of Applied Biology Overseas".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Prof. A. C. Menzies: "Modern Trends in Spectroscopy" (Peter Le Neve Foster Lecture).

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

MANCHESTER STATISTICAL SOCIETY (at the Reform Club, King Street, Manchester), at 5.30 p.m.—Mr. R. Silvey: "The Methods by which the B.B.C. Endeavours to Measure Viewing".

ROYAL MICROSCOPICAL SOCIETY (in the Hastings Hall, B.M.A. House, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. M. H. Mannering and Miss P. Davis: "Mouldlike Growth in certain Bacteria".

BRITISH INSTITUTION OF RADIO ENGINEERS, NORTH-EASTERN SECTION (at the Neville Hall, Westgate Road, Newcastle-upon-Tyne), at 6 p.m.—Mr. H. J. Barton Chapple: "A Survey of Television Development and its Problems".

SOCIETY OF CHEMICAL INDUSTRY, NUTRITION PANEL of the FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Dr. J. Sword and Miss A. M. Copping: "Factors in Distribution affecting the Quality and Nutritive Value of Foodstuffs, 2, Cereals".

SOCIETY OF CHEMICAL INDUSTRY, BIRMINGHAM AND MIDLAND SECTION (joint meeting with the FINE CHEMICALS GROUP, in the University Mason Theatre, Edmund Street, Birmingham), at 6.30 p.m.—Mr. A. R. Lockwood: "Dextran Blood Plasma Substitute".

ROYAL STATISTICAL SOCIETY, TEES-SIDE SUB-GROUP of the INDUSTRIAL APPLICATIONS SECTION (at the William Newton School, Norton, Stockton), at 7.15 p.m.—Mr. G. P. Sillitto: "The Number of Observations required in Experiments".

Thursday, December 14

PHYSICAL SOCIETY, OPTICAL GROUP (in the Physics Department, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Scientific Papers.

PHYSICAL SOCIETY, ACOUSTICS GROUP (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 4 p.m.—Messrs. K. W. Hillier, H. Kolsky, J. R. S. Waring and A. J. King: Papers on "The Dynamic Properties of Resilient Materials".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. F. J. Cole, F.R.S.: "The History of Microdissection" (Wilkins Lecture).

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. A. S. Besicovitch: "Parametric Surfaces".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Dr. G. S. Hislop: "The Investigation of Gusts".

CHEMICAL SOCIETY, MANCHESTER SECTION (in the Chemistry Department, The University, Manchester), at 6.30 p.m.—Scientific Papers.

INSTITUTE OF METALS, SHEFFIELD SECTION (at the Grand Hotel, Sheffield), at 6.30 p.m.—Mr. R. Haynes: "The Isothermal Transformation of Copper-Base Alloys".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

TEXTILE INSTITUTE, KIDDERMINSTER AND DISTRICT SECTION (in the Staff Canteen, Carpet Trades, Ltd., Kidderminster), at 7.30 p.m.—Mr. R. H. K. Thomson: "Ardil".

Friday, December 15

BIOCHEMICAL SOCIETY (in the Department of Biochemistry and Chemistry, Medical College of St. Bartholomew's Hospital, Charterhouse Square, London, E.C.1), at 2 p.m.—Scientific Papers.

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Wing-Comdr. H. P. Ruffell Smith: "Psychological Aspects of Instrument Presentation".

ASLIB (at the Department of Scientific and Industrial Research, Charles House (Room 411), 5–11 Regent Street, London, S.W.1), at 5.30 p.m.—Mr. F. C. Francis: Report of the Unesco Conference on the Improvement of Bibliographical Services held in Paris 7th–10th November 1950.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Mining Institute, Neville Hall, Newcastle-upon-Tyne), at 6.15 p.m.—Prof. Ir. L. Troost: "Open Water Test Series with Modern Propellor Forms; Part 3, Two-bladed and Five-bladed Propellors—Extension of the Three- and Four-bladed Series".

BRITISH INSTITUTE OF RADIOLOGY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 6.30 p.m.—Mr. Day: "Radiation Chemistry with Emphasis on Dosimetry".

INSTITUTE OF INDUSTRIAL ADMINISTRATION, MANCHESTER CENTRE (in the Reynolds Hall, College of Technology, Manchester), at 7 p.m.—Colonel C. T. Wells: "Training for Management".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Harold Spencer Jones, F.R.S.: "The Origin of the Comets".

Saturday, December 16

BRITISH PSYCHOLOGICAL SOCIETY (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. F. M. Earle: "Prognostic Value of Ability Tests at 10, 11, 12—a Four-Year Follow-up".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SENIOR SCIENTIFIC OFFICER with a degree in engineering (preferably Civil), for the Long Range Weapons Establishment, South Australia—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (December 14).

SUPERINTENDING SCIENTIST (with honours degree in physics or electrical engineering) at the Electronics Laboratory of the Department of Supply, Adelaide—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (December 14).

LECTURER and a TEMPORARY LECTURER IN THE DEPARTMENT OF BACTERIOLOGY of the Senior Medical School, Dundee—The Secretary, The University, St. Andrews (December 15).

ASSISTANT (with a degree in agriculture or equivalent qualifications) TO THE HEAD OF THE BIOLOGICAL AND AGRICULTURAL SECTION of the Technical and Scientific Register—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting G.296/50A (December 16).

ENGINEERS (Scientific and Experimental Officer grades) at the Royal Aircraft Establishment, Farnborough, particularly for experimental and design work on light mechanical engineering problems, including servos, and for work in the field of aeronautics and ballistics: (*a*) SCIENTIFIC OFFICERS (Ref. C.382/50A) with a good honours degree in appropriate subject, or equivalent qualification, (*b*) EXPERIMENTAL OFFICERS (Ref. C.383/50A) with Higher National Certificate in mechanical or light electrical engineering, or equivalent or higher qualification—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (December 16).

BIOCHEMIST (with a degree in biochemistry or physiology) in the Veterinary Research Division of the Ministry of Agriculture, Stormont, Belfast—The Secretary, Civil Service Commission, Stormont, Belfast (December 19).

ASSISTANT TEACHER (with a degree or equivalent qualification in chemistry) to teach Inorganic Chemistry to Higher National Certificate standard at the Widnes Municipal Technical College—Mr. W. R. Wainwright, Education Office, Lugsdale Road, Widnes, Lancs.

ASSISTANTSHIP IN RESEARCH (the holder of the post will be expected to devote his time to the application of electronic techniques to spectroscopy, especially in the infra-red, and to related physicochemical problems)—Dr. N. Sheppard, Department of Colloid Science, The University, Cambridge.

CHEMISTS (Experimental Officer grade) in Ministry of Supply Research and Development Establishments mainly in the south of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.704/50A.

PRINCIPAL-DESIGNATE OF THE NEW INSTITUTE OF HORTICULTURE, which will be established near Pershore—The Director of Education, Castle Street, Worcester.

PROFESSOR OF AGRICULTURE (Soil Science) in the School of Agriculture, Canterbury Agricultural College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1.

REGIONAL TRIALS OFFICER (with a university degree or diploma in agriculture and/or biology)—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

RESEARCH ASSISTANT (young woman, recently graduated in biological sciences)—The Sir William Dunn School of Pathology, South Parks Road, Oxford.